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A Comparative Study of the Effectiveness of the Greek National Men's Volleyball Team With Internationally Top-Ranked Teams

Laios Yiannis, Kountouris Panagiotis, Aggelonidis Ioannis and Katsikadelli Alkinoi (Greece)

The present study compared the total effectiveness and performance of the game play of the Greek National Men's Volleyball Team with the internationally top-ranked teams. The purpose of the investigation was to reveal the specific skills at which it most likely lags behind. Twenty-six volleyball matches from three international-level tournaments were video-recorded. In total, 1,542 phases-points were analyzed. As a result of the analysis, it was found that the Greek team was not inferior to the top 5 teams with regard to service. The Greek team had a significantly greater proportion of aces. This benefit does not compensate for the concurrent greater proportion of lost serves as a consequence of the greater risk embedded in their execution. Greece's capabilities in reception and kill attacks were also not inferior to those of the top-ranking teams. Greece did not, however, have the same capacity to encompass a positive defense beyond the block. When serve reception was not optimum, Greece lagged behind both in the proportion of kill attacks and positive defense beyond the block. Greece also exhibited an inferior potential for cover attacks.

Key words: Volleyball, skills, effectiveness, ranking, setting time

~~La présente étude a effectué une comparaison de la toutes les efficacité et exécution du jeu de jeu de l'équipe grecque de volleyball du national men's avec les équipes internationalement supérieures de rang. Le but de la recherche était d'indiquer les qualifications spécifiques auxquelles il les retards le plus susceptibles derrière et par conséquent dû travailler dessus et s'améliorer. Un total de 26 allumettes de volleyball de trois tournois d'international niveau ont été enregistrés en vidéo. Au total, 1542 phase-points ont été analysés. Les résultats de l'anaylsis ont fourni l'évidence que l'équipe grecque n'est pas inférieure aux 5 équipes principales quant aux erreurs de service et n'a pas en fait une proportion sensiblement plus grande de services perdus, par suite du risque plus grand inclus dans l'exécution. Les possibilités de La Grèce dans des attaques de réception et de kuill ne sont pas inférieures à ceux des équipes supérieures de rang. La Grèce n'a pas la même capacité aux emcompass une défense efficace entourer le bloc. Quand la réception de service n'est pas optima les retards de la Grèce derrière dans la proportion d'attaques de mise à mort et dans la défense efficace de proportion environnante bloquent.~~

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INTRODUCTION

The amendments to the rules of the game of volleyball during the past 15 years have affected significant changes in game strategy and tactics. The primary reason for the introduction of new rules, specifically the rally point system, was that the game of volleyball needed to adapt to a more reasonable time frame for television broadcasting (Thinnes, 1992; Van Aartrijk, 2000), while at the same time be more spectacular and attractive to spectators (Berjaud, 1995; Kountouris et al., 2001).

The implementation of the new rules came into effect Jan. 1, 2000 (FIVB, 1999). The implementation brought two significant changes to the game:

1. Homogeneity in its duration, since all sets were played with the same rules.
2. Modification of temporal structure because the team was rewarded for each positive play and punished for every play resulting in an error.

The consequences of these changes were:

1) The significant decrease in the duration of sets and, therefore, the game (Kountouris & Laios, 2000a and 2000b).
2) The change in the way a team wins a point. A team wins a point, not only by an effective completion of a phase, but also by negating the opponent's plans with:
   a. a successful service execution
   b. any attacking action
   c. a successful block
   d. an error by the opponent.

It has also been reported that both the players' and the team's performances are closely related to the current structure of the

game and the rules by which they are governed (Zimmermann, 1999). The players must focus and react to different situations and personal performances, with regard to the execution of a successful action in the game and depend on the timely recognition of game evolution and quick movement in the court area (Ahrabi-Fard & Huddleston, 1996).

Regardless of the rule changes, the game is constructed by a series of individual skills that are directly related to the team's performance and proficiency. In comparative evaluations of the game's skills, it has been shown that the attack is the first priority (Cox, 1974a and 1974b; Yoshida & Toshiaki, 1985; Nishijima, 1986; Nishijima, 1987). It was also shown that the attack, together with the setter's pass, constituted the major share of a volleyball team's performance.

From the 1994 World Volleyball Championship to the Atlanta Olympic Games in 1996, only a few of the new tendencies of the game were confirmed and even fewer were added with regard to the effect on the game play and the performance of the teams during the game (Froehner & Zimmermann, 1996a). Epigrammatically, these trends and additions were related to the high frequency of the games that resulted in the players' fatigue, the swift and dynamic preparation of new players for their immediate enrollment in the team's dynamic, the systematic use of the basic composition of the teams with simply shifting of places according to the opponent for ensuring the team's steady performance and finally the employment of scientific methods and technology (Froehner & Zimmermann, 1996b and 1996c).

After the implementation of the new regulations and despite the fact that the above tendencies are still prevalent in high-level volleyball, the rally point system compelled both players and trainers to focus their attention on avoiding errors that would reward the opponent with an easy point. Thus, many teams continue to strive toward perfect execution of the basic skills in conjunction with pursuing and applying new tactics that ensure faster passing to the attackers, enhanced effectiveness of the block concurrent with successful ground defense and improvement of the service that makes it more challenging for the reception.

During the past few years, the men's national volleyball team of Greece participated in a number of high-level tournaments (World Championship and World Leagues) and achieved a number of notable accomplishments. However, it has never been included in the elite of world volleyball. According to the official world ranking issued by the International Volleyball Federation (FIVB) on Dec. 1, 2003, Greece was 13th. The best five national teams (Top 5), according to the same classification are shown in Table 1.

The purpose of this study was to compare the total effectiveness and performance of game play of the Greek team with the one demonstrated by the Top 5 teams. The purpose was to reveal the differences and determine specific skills which most likely need improvement that can lead to the establishment of the men's national team of Greece in the top rankings.

Ranking	Team	Points
1.	Brazil	277.00
2.	Italy	226.50
3.	Serbia & Montenegro	221.25
4.	France	147.75
5.	Russia	134.00
13.	Greece	50.50

Table 1.

FIVB World Ranking – December 1, 2003.
Final ranking valid for 2004 Olympic Games Qualification Process

Competition	Matches	Comments
Olympic Games Sydney 2000	4	The 2 semi-finals and 2 finals
World League 2001	10	The matches of the group in which Greece participated.
World Championship 2002	12	The matches of the final qualification games for places 1-6 and all the matches of Greece (7th).

Table 2.

Matches videotaped for further analysis.

METHODS

Twenty-six volleyball matches were videotaped from three international-level tournaments, as shown in Table 2. All videos were recorded from behind the endline and imported to a PC for further analysis with the use of the software program VirtualDub 159. A total of 35 variables were recorded, 12 of which characterized the competition, the match and the teams; 23 parameters were used for the detailed analysis of each point. Herein are the variables and coding used for further analysis:

A. Type of service (1=jump serve, 2=jump floating serve, 3=floating serve with no jump).
B. Service Time (ST) in seconds - the time from the moment the server strikes the ball until it is touched by the receiver or it touches the net or ground.

C. Reception Result [1=Ensures presuppositions for 1st-tempo attack (R1); 2=Attack is forcibly 2nd- or 3rd-tempo (R2); 3=No setting can be accomplished; 4=Receptor gives a point; 5=Reception passes immediately to the opponent's court; 6=Receptor does not touch the ball (Ace); 7=No reception because the ball went out or on the net (Fault)].
D. Setter's Pass Time (PT) in sec, which is the time from the moment that the ball leaves the setter's hand until it is hit by the attacker.
E. Attacker [1=Outside or diagonal (OH); 2=Middle blocker (MB)].
F. Attack result [1=Wins a point (Kill attack); 2=Game continues with the same team in the attack (Cover attack, which gives the presuppositions for a second attack); 3=Game continues with the opposing team in the attack (Counter attack); 4=The block wins the point (Kill block); 5=The ball goes in the net or out-of-bounds (Fault)].

Statistical Analysis

In accordance with the purpose of the study, the primary pairwise comparisons were when Greece was serving and the Top 5 were receiving (Condition 1) and when the Top 5 were serving and Greece was receiving (Condition 2). The results were also compared with matches where both the serving and the receiving teams were in the Top 5 (Condition 3).

Service and setting times were compared with ANOVA and post-hoc Bonferroni pairwise comparisons. All the other variables formed frequency distributions; the primary comparison analysis was carried out with the use of chi-square test and, subsequently, with the binomial test. Statistical significance was set at 0.05.

RESULTS AND DISCUSSION

In total, 1,542 phases-points were analyzed. Table 3 shows the absolute and percentage distribution of the types of service executed. It appears that Greece utilized the jump serve against the Top 5 in the same proportion with the Top 5 against Greece. When the Top 5 played each other, however, they utilized other types of serves in a greater proportion (chi-square test, $p<0.05$).

Service Kind	Condition 1	Condition 2	Condition 3
Jump serve	285 (84.3%)	299 (85.2%)	600 (70.3%)
Jump floating serve	52 (15.4%)	34 (9.7%)	187 (21.9%)
Floating serve	1 (0.3%)	18 (5.1%)	66 (7.7%)
Total	338	351	853

Table 3.
Absolute and percentage distribution of types of serves. Condition 1=Greece serves Top 5 receive; Condition 2=Top 5 serve Greece receives; Condition 3=Top 5 serve and receive.

These findings confirm conclusions of a number of researches with regard to the prevalence of jump serves in high-level volleyball (Katsikadelli, 1995, 1996, 1998; Aggelonidis 2004). On the other hand, it seems that when the top-ranked national teams play each other, servers revert more readily to float serves, apparently for tactical reasons (Froehner & Zimmermann, 1996a).

Notwithstanding the differing serving tactics applied, the jump serve still remains the primary choice of high-level teams. Hence, further analysis of the subsequent game skills is restricted to only this kind of service. The mean flight time of the jump serve of all the teams was practically the same, with a mean value of 0.76±0.17sec.

Figure 1 depicts the percentage of points directly won (aces) from execution of the jump serves in all three conditions under consideration. It also shows the percentage of directly lost points

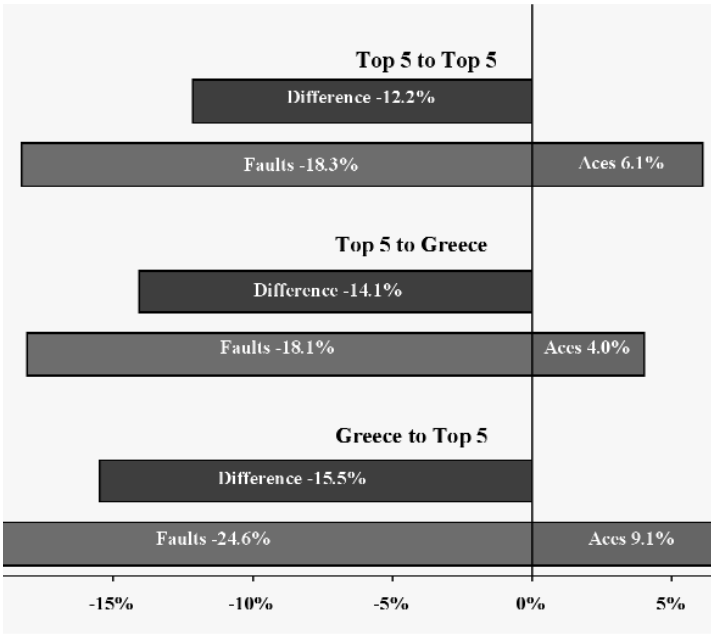

Figure 1.
Percentage of aces, errors and their differences after execution of jump serves for the three conditions under consideration.

(errors), as well as the percentage difference between errors and aces. Greece had won a significantly greater proportion of aces than the Top 5 (binomial test, $p<0.05$), but at the same time it had a significantly greater number of errors (binomial test, $p<0.05$). The result is that the difference of errors-aces was not in favor of Greece, though not in a significant manner. The fact that Greece won a significantly higher proportion of aces than the top-ranked teams should be evaluated with the concomitant higher proportion of lost serves, which to all appearances was a consequence of a more risky execution.

Table 4 shows the setter's mean Pass Times (PT) in s and percentage proportion of passes to the middle blocker (MB) and the outside hitter (OH) after a perfect (R1) and non-perfect (R2) reception. For R2, no percentage distribution is shown, since practically after R2, passes can only go to the OH.

	MB, R1		OH		
			R1		R2
	PT	%	PT	%	PT
Condition 1	0.40±0.06	30.9%	1.18±0.14	69.1%	1.58±0.29
Condition 2	0.40±0.10	28.8%	1.14±0.14	71.2%	1.56±0.24
Condition 3	0.40±0.08	31.7%	1.09±0.14	68.3%	1.51±0.28

Table 4.

Setter's mean Pass Times (PT) in s and percentage proportion of passes to middle blocker (MB) and outside hitter (OH) after a perfect (R1) and non-perfect (R2) reception. Conditions are the same as in Table 3.

The pass times to the middle blocker after a perfect reception did not differ between Greece and the Top 5, while pass times to the OH for Greece were slower than for the Top 5. This difference achieves statistical significance in the case of a perfect pass (post-hoc Bonferroni comparison, $p<0.05$). The distributions of passes to the MB and the OH were practically the same for Greece and the Top 5. After a perfect reception there is homogeneous ratio of the number of sets to the MB and the OH. It seems, however, that Greece was slower in setting to the OH.

Table 5 shows the proportion of perfect (R1) and non-perfect (R2) receptions to the total number of receptions for the three conditions. Within the total number of R1 and R2 receptions, the proportion of kill attacks of the receiving team and successful defenses of the serving team is shown. A successful defense is one that gives the opportunity to the serving and, subsequently, defending team after an opponent's attack to execute a counter attack and gain the point.

	R1			R2		
	R1/total receptions (%)	Kill attacks (%)	Successful defenses (%)	R2/total receptions (%)	Kill attacks (%)	Successful defenses (%)
Condition 1	59.5%	57.6%	14.4%	20.0%	41.0%	17.1%
Condition 2	64.5%	58.4%	21.0%	23.3%	33.9%	22.8%
Condition 3	64.9%	57.0%	18.0%	21.8%	36.4%	30.8%

Table 5.

Proportion of perfect (R1) and non-perfect (R2) receptions and proportion of kill attacks and successful defenses after R1 and R2.

After R1, although Greece had the same effectiveness in kill attacks as the Top 5, it lags behind in its defense (binomial test, $p<0.05$). A likewise decline of defense capability was observed in R2 (binomial test, $p<0.05$). More important in R2 was Greece's inferior attack effectiveness, as it was expressed by the proportion of kill attacks (binomial test, $p<0.05$). The same reduced effectiveness was found in Greece's ability for cover attack, where the corresponding percentages (not shown in the table) were 17.1% for the Top 5 and 10.9% for Greece (binomial test, $p<0.05$).

Greece's capabilities in reception and subsequent kills were by no means inferior to those of the top-ranked teams. Nonetheless, Greece did not seem to have the same capacity to encompass a positive defense beyond the block to the same extent as the top-ranked teams. When the reception was not perfect, Greece lagged behind both in the proportion of kill attacks and positive defense beyond the block. Greece also exhibited an inferior potential to cover attacks.

Table 6 (see page 8) shows the percentage of kill blocks and counter-attacks, affected by serving, as well as points won by the receiving team with block-out. While Greece managed the same proportion of kill blocks and counter-attacks after the opponent's R1 and subsequent attack, it had a greater proportion of block-outs (binomial test, $p<0.05$). After the opponent's R2 and subsequent attack, Greece managed a significantly lower proportion of kill blocks and counter attacks (binomial test, $p<0.05$). Even more impressive were the differences in second attack of the same team after the return of the ball from the block to the at-tacking team [8.1% for the Top 5 and only 1.3% (binomial test, $p<0.05$) for Greece after R1 and 14.6% and 10.5% (binomial test, $p<0.05$) correspondingly after R2].

After a perfect reception, Greece's increased number of lost points from block-outs may be partially due to the increased speed of the opponents' setting to the attacker. After a non-perfect reception, Greece's weaknesses were also expressed in the proportion of kill blocks, as well as counter attacks.

CONCLUSION

A national volleyball team striving toward the elite of world volleyball must compare the effectiveness of its skills with the effectiveness of the skills of the elite. This calls for thorough analysis of videotaped matches from international-level tournaments. The validity of the statistical inferences is ascertained by the inclusion of a sufficient number of data over a reasonable time period. The application of the above considerations in the current study's methodology led to the conclusion that the Greek men's national volleyball team, though not inferior to the top 5 ranked teams with regard to service, reception and kills

	R1			R2		
	Kill Block (%)	Counter-attack (%)	Block-out (%)	Kill Block (%)	Counter-attack (%)	Block-out (%)
Condition 1	10.2%	10.6%	26.8%	14.6%	2.4%	17.1%
Condition 2	10.5%	9.9%	19.7%	26.3%	10.5%	14.0%
Condition 3	7.2%	7.3%	17.2%	9.3%	10.3%	15.9%

Table 6.

Proportion of kill blocks, counter-attacks and block-outs after R1 and R2.

attacks, exhibited an inferior potential primarily in the positive defense beyond block and cover attacks.

IMPLICATIONS FOR COACHING

It is important for coaches to analyze, in detail, as many variables that affect team performance as possible. This study adds credence to the above statement. The use of videotape performances is a tremendously viable tool for such detailed analysis.

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BIO INFORMATION NEEDED

A Comparison of Positional Jumping Characteristics of NCAA Division I College Women's Volleyball Teams: A Follow-up Study

Jason D. Vescovi, University of Connecticut and
Lauren T. Dunning, The George Washington University (USA)

The purpose of this investigation was to examine positional variations between NCAA Division I female volleyball teams and determine if positional jump type volume varies between levels of play within Division I female volleyball. Retrospective video analysis of six matches was performed for four teams from the 2001 and 2002 seasons. The volume of each jump type (spike, block, dive, jump serve, or jump set) was recorded for the outside hitter (OH), middle blocker (MID), and setter (SET). Teams were classified as elite (E) or non-elite (NE). A 3 X 4 ANOVA (position X game) showed significant main effects for games and position for E ($p=0.048$) and NE ($p=0.002$), respectively. Game 4 jumping volume was significantly lower vs. games 1-3 ($p<0.04$) for E, while SET performed significantly more jumps vs. OH and MID ($p<0.006$) for NE. A 3 X 5 ANOVA (position X jump type) indicated significant interactions ($p<0.000$) for both E and NE. Significant differences were found for jump type volume between positions (except for dive) ($p<0.025$), as well as within each position for the various jump types ($p<0.000$) for both groups. A 3 X 5 X 2 (position X jump type X group) ANOVA indicated a significant interaction with differences for OH (jump serve), MID (jump serve), and SET (all except dive) between E and NE. These data illustrate the positional differences for the various jumps performed during Division I female volleyball competition. Regardless of E or NE status, programs designed for power development should consider these specific positional differences.

Key words: volleyball, needs analysis, specificity, plyometrics

~~La présente étude a effectué une comparaison de la toutes les efficacité et exécution du jeu de jeu de l'équipe grecque de volleyball du national men's avec les équipes internationalement supérieures de rang. Le but de la recherche était d'indiquer les qualifications spécifiques auxquelles il les retards le plus susceptibles derrière et par conséquent dû travailler dessus et s'améliorer. Un total de 26 allumettes de volleyball de trois tournois d'international niveau ont été enregistrés en vidéo. Au total, 1542 phase points ont été analysés. Les résultats de l'anaylsis ont fourni l'évidence que l'équipe grecque n'est pas inférieure aux 5 équipes principales quant aux erreurs de service et n'a pas en fait une proportion sensiblement plus grande de services perdus, par suite du risque plus grand inclus dans l'exécution. Les possibilités de La Grèce dans des attaques de réception et de kuill ne sont pas inférieures à ceux des équipes supérieures de rang. La Grèce n'a pas la même capacité aux emcompass une défense efficace entourer le bloc. Quand la réception de service n'est pas optima les retards de la Grèce derrière dans la proportion d'attaques de mise à mort et dans la défense efficace de proportion environnante bloquent.~~

Le but de cette recherche était examiner des variations de position entre les équipes féminines de volleyball de la Division I de NCAA et de déterminer si le volume de position de saut change entre les niveaux du jeu dans le volleyball de femelle de la Division I. L'analyse visuelle rétrospective de six allumettes a été exécutée pour quatre équipes des 2001 et 2002 saisons. Le volume de chaque type de saut (transitoire, bloc, piqué, service de saut, ou saut réglé) a été enregistré pour le cogneur extérieur (OH), le dresseur moyen (MI), et le poseur (PLACEZ). Des équipes ont été classifiées comme élite (e) ou non-élite (Ne). Effets principaux significatifs montrés de 3x4 Un ANOVA (jeu de position X) pour des jeux et position pour E ($p=0.048$) et NE ($p=0.002$), respectivement. Le volume sautant du jeu 4 était sensiblement inférieur contre des jeux 1-3 ($p<0.04$) pour E, SET exécuté sensiblement plus des sauts vs. OH et MID ($P<0.006$) pour tous les deux E et NE. Des différences significatifs ont été trouvés pour le type volume de saut entre les positions (excepté le dive)($p<0.025$), aussi bien que dans chaque position pour le divers saut dactylographie pour les deux groupes($p<.000$). Un 3x5x2 (position x sautez le type X groupe) ANOVA a indiqué une interaction significative avec des différences pour OH (service de saut), MID (service de saut) et SET (tous excepté le piqué) entre E et NE. Ces données illustrent les différences de position pour différents sauts exécutés pendant la concurrence de volleyball de femelle de la Division I. Indépendamment de E ou de statut de Ne, les programmes conçus pour le développement de puissance devraient considérer ces différences de position spécifiques.

INTRODUCTION

Texts and journal articles written for and by sports performance professionals typically indicate that needs analyses are essential elements within training program design processes. A detailed needs analysis will provide the strength and conditioning professional valuable information regarding the general characteristics of a sport, as well as insight to positional differences that may exist. For example, the average sprint duration of top-class soccer players is 2 seconds or 17 meters long (Hasegawa, Dziados, Newton, Fry, Kraemer, & Hakkinen, 2002; Kirkendall, 2000). Ice hockey is characterized by repeated directional changes and 2-second accelerations, but work-to-rest ratios may differ between offensive and defensive players (Pollitt, 2003). Quantitatively understanding that different characteristics exist between various positions within a particular sport (Meir, Newton, Curtis, Fardell, & Butler, 2001; Schmidt, 1999; Shields, Whitney, & Zomar, 1984)

should enable sports performance professionals to develop a training program that prepares a player for the demands of a sport and, if necessary, maximizes their potential for a specific position.

A volleyball match is played to the best of 5 games and is characterized as an anaerobic power sport with rallies lasting fewer than 10 seconds in duration. The match includes approximately 4 directional changes and various types of jumping (e.g., spiking and blocking) (Hasegawa, Dziados, Newton, Fry, Kraemer, & Hakkinen, 2002; Schmidt, 1999). Jump characteristics have been reported for men's and women's volleyball (Belyaev, 1985; Lecompte & Rivet, 1978; Narr, 1982; Rivet, 1979), but most of the research is limited to the time period it was collected (1970s and 1980s) and may not accurately reflect the current characteristics of college volleyball. For instance, Belyaev (1985) reported elite male volleyball players perform between 155-185 jumps per match, which corresponds to approximately 31-37 jumps per game. Rivet (1979) showed women performed, on average, 12 jumps per game with a maximum of 35. These data provide broad information regarding the volume of jumps, but do not quantify which types of jumps are most often performed by each position. From this information, only a generalized training program can be developed to target jumping ability without much regard for differing volumes of jumps performed by the outside hitter (OH), middle blocker (MID), or setter (SET). Therefore, a higher degree of specificity is necessary when conducting a needs analysis in order to assess differences occurring between positions accurately.

Recently, Vescovi and Dunning (2001) quantified positional differences for NCAA Division I female college volleyball players. As expected, outside hitters, middle blockers, and setters performed a greater number of spikes, blocks, and jump sets, respectively, compared to each other. Nevertheless, even within NCAA Division I programs, a disparity may exist for overall jump volume, as well as specific jump type volume between elite and non-elite teams. Therefore, the purpose of this investigation was to determine if similar positional variations exist for elite teams compared to other programs and examine if positional jump type volume varies between levels of play for NCAA Division I female volleyball teams. It was hypothesized similar distinctions between positions would exist for elite teams, but jumping volumes for the various jump types would differ compared to non-elite teams.

METHODS AND PROCEDURES

Experimental Approach to the Problem. A cross-sectional study design was used to examine the hypothesis. Retrospective video analysis from the 2001 and 2002 seasons was performed for four NCAA Division I women's volleyball teams. Two of the teams were ranked nationally in the top 25 and advanced to at least the quarterfinals of the NCAA championship and were therefore considered elite (E), while the other two teams held regional rankings only and were regarded as (non-elite, NE). Six matches were analyzed for each position (OH, MID, SET), with a total of 22 games for each group. Jumps were classified as spike, block, jump set, jump serve, or dive and were recorded only when both feet were off the ground simultaneously. Ball contact and rally outcome were disregarded when tabulating jumps.

Statistical Analysis. All analyses were performed using SPSS version 11.0. The dependant variable, jump volume, was examined using several 2-way and 3-way ANOVAs. A 3 X 4 ANOVA included position (OH, MID, SET) and games (1, 2, 3, 4) as the independent variables. A 3 X 5 ANOVA examined the relationship between position and jump type (spike, block, dive, jump set, jump serve). Team status was added to the analysis using a 3 X 4 X 2 (position X game X group) and 3 X 5 X 2 (position X jump type X group) design to compare the jump volumes for games and jump type between E and NE. A significant F-ratio was followed by LSD post-hoc comparisons. Values are mean + SD. Significance was accepted at $p < 0.05$ for all analysis.

RESULTS

No significant interaction was found for E or NE; however, a significant main effect for games and position was found for E ($p=0.048$) and NE ($p=0.002$), respectively (Figure 1). Univariate analysis indicated jumping volume in Game 4 was significantly

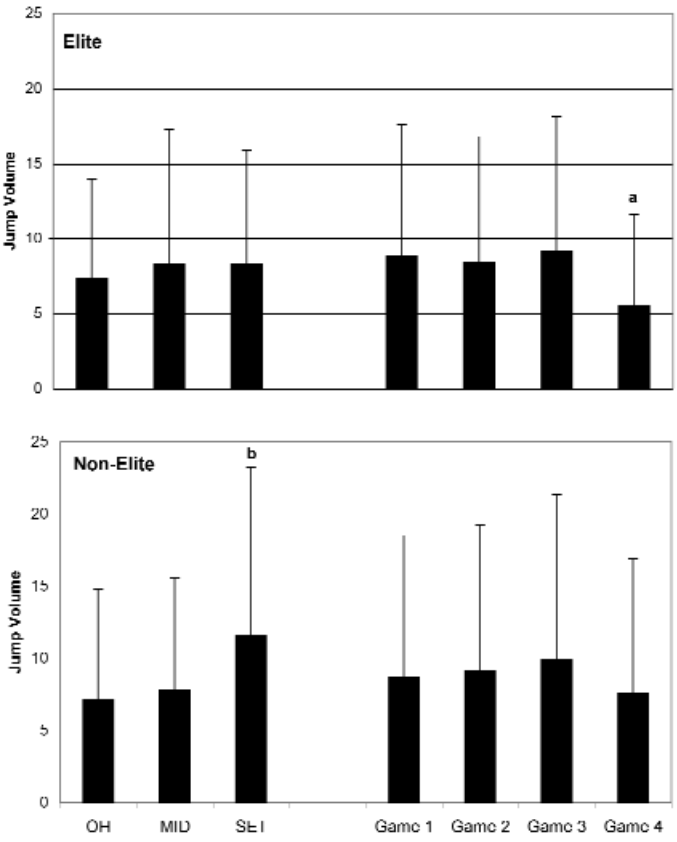

Figure 1.
Average jump volume for each position and each game for elite (top) and non-elite (bottom) teams. a = significantly different from other games. b = significantly different from other positions.

lower compared to games 1-3 ($p<0.04$) for E, but pairwise comparisons found no difference between games within each position ($p>0.05$). SET performed significantly more jumps per game compared to OH ($p=0.001$) and MID ($p=0.006$) for NE.

The 3 X 5 (position X jump type) ANOVA indicated significant interactions ($p<0.000$) for both E and NE. Univariate tests showed significant differences in jump type volume within each position ($p<0.000$) (Figure 2, page 12), as well as between positions (Figure 3, page 13), ($p<0.025$) for the various jump types for both groups. For E, within position differences were observed for all pairwise comparisons except dive vs. jump serve (OH) and

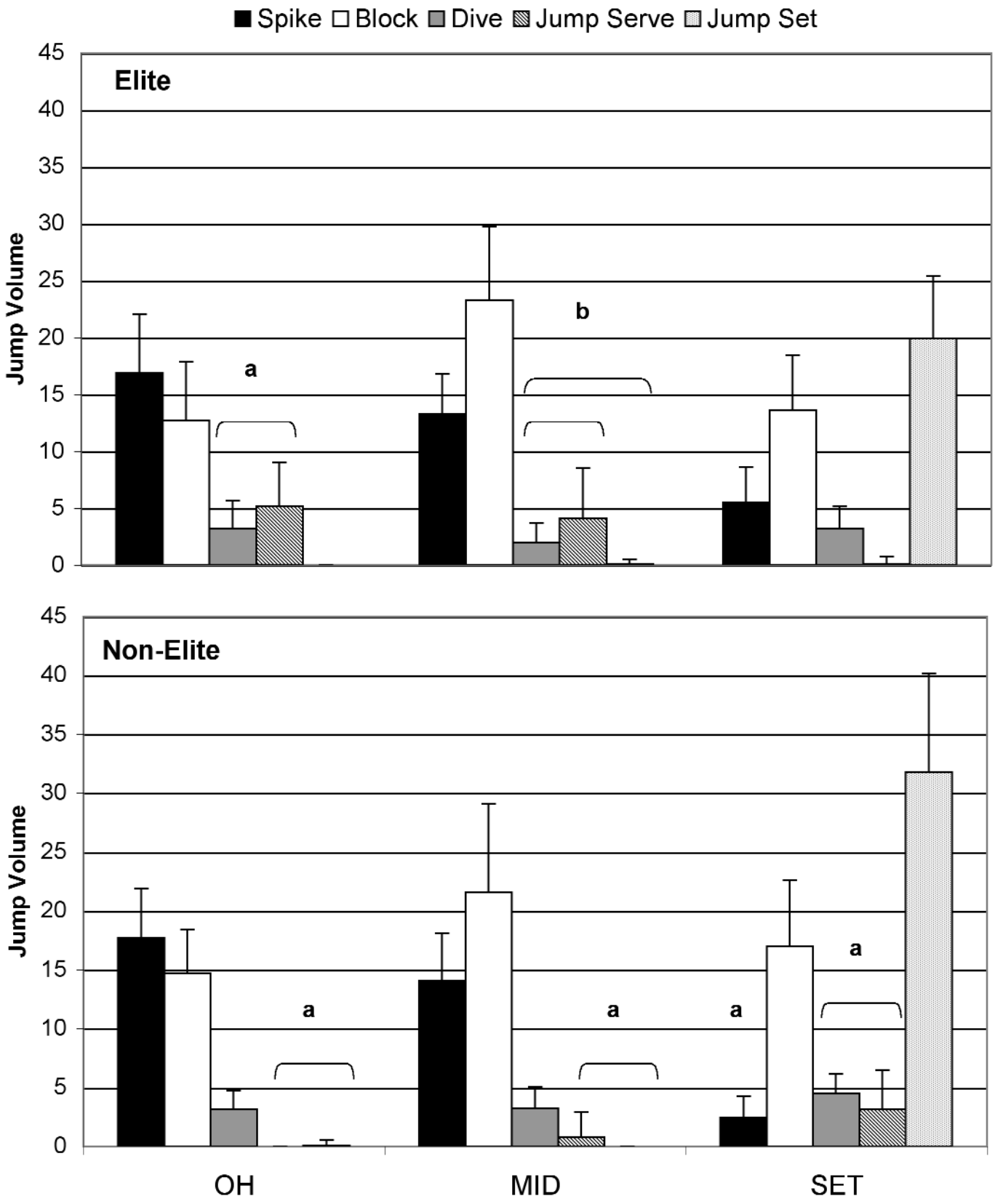

Figure 2.
Positional jump type volumes. a = NS compared to each other; all other within position volumes differ significantly. b = dive not significantly different from jump serve or jump set; all other within jump type volumes differ significantly.

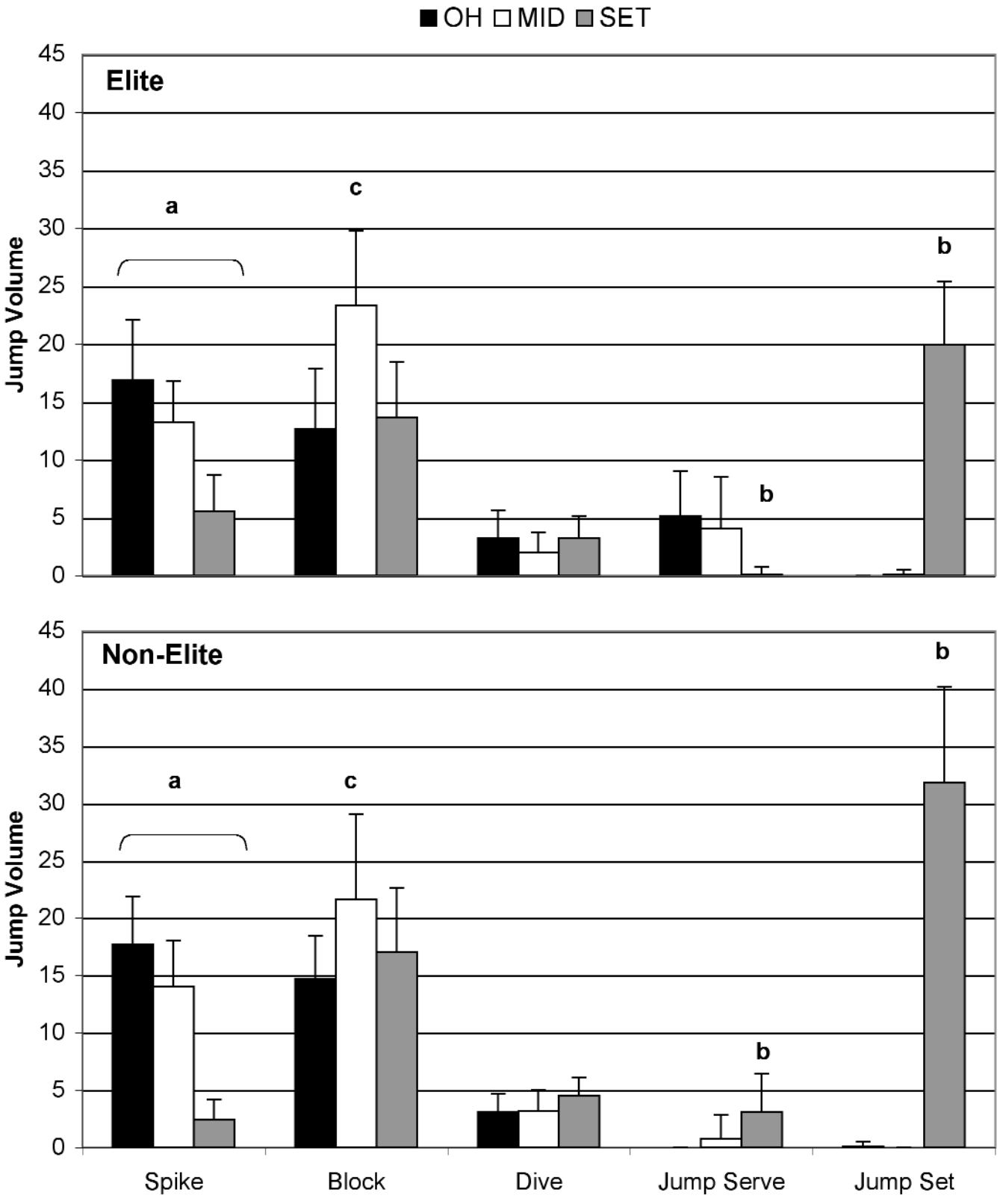

Figure 3.
Jump type volumes for each position. a = all comparisons are significantly different. b = SET significantly different from OH and MID. c = MID significantly different from OH and SET.

dive vs. jump set and jump serve (MID). Pairwise comparisons for NE showed significant differences for each jump type except for jump serve vs. jump set (OH and MID) and spike, dive, and jump serve for SET. Between position pairwise comparisons indicated similar significant differences for E and NE (Figure 3).

Results showed no significant effects of team status on jump volume for each position between games (data not shown). There were, however, significant pairwise differences for jump type volume between E and NE. Elite OH and MID performed more jump serves ($p<0.000$) and SET performed more spikes ($p=0.01$) compared to NE. Non-elite SET performed more blocks, jump serves, and jump sets ($p<0.01$) compared to E (Figure 4).

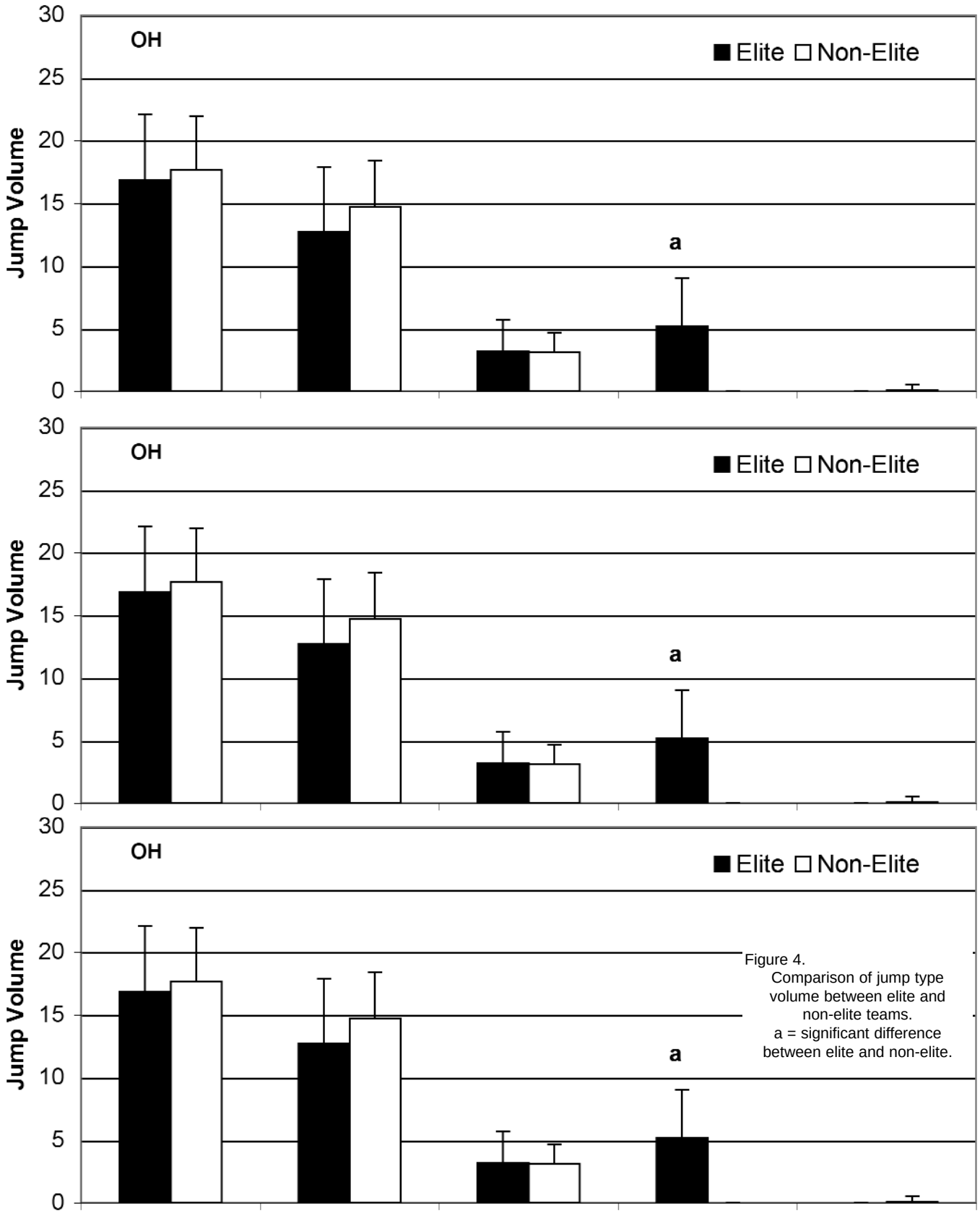

Figure 4.
Comparison of jump type volume between elite and non-elite teams.
a = significant difference between elite and non-elite.

DISCUSSION

The total jump volumes for E and NE parallel; however, a few unique differences exist. For example, SET perform significantly more jumps compared to OH and MID for NE, whereas all 3 positions for E showed nearly identical volumes. The mean volume for SET is inflated due to a larger volume of jump sets, though it is unclear why more jump sets would be performed for NE. Nevertheless, as has previously been shown (Vescovi & Dunning, 2003), there remains a narrow range for mean jump volume (approximately 7-11 jumps per game) and a high degree of similarity between positions. These values are slightly less than reported by Rivet (1979), who showed an average of 12 jumps per game by female volleyball players.

Mean game volume showed significantly lower values for Game 4 within E. One possible explanation for this finding is that whichever team had a 2–1 advantage proceeded to dominate game 4, winning the match. Regardless, mean game jump volume remains less than 10 for both groups, indicating a relatively small number of jumps performed (30-40) for an entire match. These results are misleading and would support the development of a standardized training program to enhance jumping ability for college female volleyball players.

A more accurate representation is developed when specific jump volumes are determined for each jump type. For example, 44% and 50% of OH jumps are spikes; 55% of MID jumps are blocks; 47% and 54% of SET jumps are jump sets for E and NE, respectively. Table 1 outlines the range of specific jump volumes for each position. Expected positional jump type specificity was observed; however, an interesting note is that MID perform significantly more spikes than SET, but fewer than OH. It appears MID have a unique contribution to the game of volleyball both on offense and defense, whereas OH and SET seem to split the responsibility to assist MID defensively.

Non-elite SET perform more jumps compared to MID and OH, indicating fatigue could potentially affect performance later during a match; however, the larger overall volume is almost entirely due to a greater amount of jump sets. Anecdotally, jump sets are typically sub-maximal and appear less intense than either a spike or maximal block jumps. Therefore, performing a larger volume of sub-maximal jump sets may create less fatigue during the course of a match compared to smaller volumes of high intensity jumps. Rodaki and colleagues (2001) have reported a 10% decrease in time to peak power and an increase in contraction times for jumping ability following fatigue. Substitution patterns, then, as well as seasonal playing time, could be monitored by keeping track of jump volumes. Longitudinal investigations should examine the changes in power production during the course of a match, tournament play, and an entire season to elucidate how jump volume impacts each position.

Training for volleyball typically focuses on the development of explosive power, which will involve multi-joint, closed kinetic chain resistance exercises, as well as plyometric training. The volume of plyometric exercises chosen for volleyball players should be based on the specific positional requirements presented in the current investigation, and must also be guided by intensity and movement specificity. Although not scientifically quantified, it could be argued the intensity of jump type increases from jump sets (low) to maximal block jumps (medium) and finally spikes (high) (i.e., jump sets < block jumps < spikes). Therefore, exercise selection and prescription for SET should include a mixture of low- and high-level vertical jumping using high volumes to focus on fatigue resistance. Specificity also dictates the inclusion of lateral movements and/or rotation of the body prior to performing a vertical jump with the arms extended overhead.

It appears MID provide more offensive support (i.e., spiking volume) compared to SET and a training program should reflect these differences. For example, approximately 1/3 of the exercises used should focus on spiking ability, with one caveat: the type of approach used to spike by MID was not examined in this study. Future studies should examine if MID perform a 3-step approach

Table 1. Range of Jump Volume for 3-4 Game Match

	Spike	Block	Dive	Jump Serve	Jump Set	Total
Elite						
OH	50 - 67	38 - 51	10 - 13	15 - 21	< 1	113 - 152
MID	40 - 53	70 - 93	6 - 8	12 - 16	< 1	128 - 170
SET	17 - 22	41 - 54	10 - 13	< 1	60 - 80	128 - 169
Non-Elite						
OH	53 - 71	44 - 59	9 - 12	< 1	< 1	107 - 143
MID	42 - 56	65 - 86	10 - 13	2 - 3	< 1	119 - 158
SET	8 - 10	51 - 68	14 - 18	9 - 12	95 - 127	177 - 235

OH – Outside hitter; MID – Middle blocker; SET – Setter.

jump or if the approach is simply a blocking movement with a quick offensive or defensive arm swing action.

Movement specificity will play a major role in exercise selection for outside hitters, whereby their primary action requires the ability to accelerate in the anterior-posterior plane, utilize an effective stretch-shortening cycle, and finally produce power in the vertical axis. Exercises should include high-intensity jumps with the primary focus on horizontal acceleration development and maximum vertical power. Exercise selection and volume for each position will ultimately be determined by many factors such as training age, playing status (novice, high school, university, professional) and the particular phase of a yearly training cycle.

The current investigation found positional differences for NCAA Division I female volleyball players. There was, however, a high degree of similarity between E and NE teams. While the differences found between positions were expected (e.g., outside hitters perform the greatest amount of spikes), the resemblance for team status was not. Nevertheless, the quantification of jumping characteristics provides a clear foundation for program design and possible improvements in volleyball performance. Future research should focus on other types of volleyball play (e.g., men, NCAA Division II or III, high school, beach etc.).

IMPLICATIONS FOR COACHING

These data provide a quantitative rationale for the development of specific jump training programs based on positional requirements of jump type volume. It appears that there are minimal differences between elite and non-elite NCAA Division I women's volleyball programs and therefore status or ranking should not factor heavily into the prescription or selection of exercises targeted at power development. A possible area for future research is the metabolic cost for each jump type. If energy expenditure can be quantified for the various jumps, then it might be possible to more accurately assess total energy expenditure of match play.

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Jason D. Vescovi, MS, CS, is a doctoral fellow in the Human Performance Laboratory, Department of Kinesiology, at the Neag School of Education at the University of Connecticut. He was a strength and conditioning consultant to The George Washington University women's volleyball team for four years (1998-2003).

Lauren T. Dunning is an exercise science major at the School of Public Health and Health Services, Department of Exercise Science, The George Washington University. Dunning was a member of the GW women's volleyball team (2000-2003), serving as the starting setter for two years, as well as the team's co-captain during the 2003 campaign.

Effects of Single-Leg Resistance Training on Measurement of Jumping Performance in NCAA Division II Women Volleyball Players

George A. Langford, Kevin W. McCurdy, Michael Doscher, and John Teetzel
Valdosta State University, Georgia (USA)

The purpose of this investigation was to determine the effect of single-leg training on vertical jump performance during a simulated spike and block at various contact and approach times in collegiate women volleyball players. Five NCAA Division II women volleyball players between the ages of 19-21 with a mean weight of 66.74 ± 8.02 kg completed the study. The participants were instructed to produce their best vertical jump during the spike and block during two trials at four different approach and contact times (time on the jumping mat). From these 8 trials, the average of the 2 highest vertical jump heights and flight time/contact time ratios were selected for analysis before and after 10 weeks of resistance training. Differences in vertical jump performance between the pre- and posttest were also analyzed from the participants' trials with similar approach and contact times. The participants' best vertical jump improved 4.27 cm on the spike and 2.38 cm on the block. The higher posttest flight time/contact ratios were not significantly different on the spike ($p = 0.48$) and block ($p = 0.06$) test after training. The improved flight time/contact time ratios at the lowest contact times approached significance on the spike ($p = 0.26$) and block ($p = 0.04$). Vertical jump height at the fastest approach speeds increased 3.30 cm and 4.98 cm on the spike and block, respectively. Vertical jump height also increased 3.81 cm on the spike test and 4.27 cm on the block test at the lowest contact times. The results indicate that single-leg resistance training is an effective method to improve double-leg jump performance on the spike and jump in NCAA Division II women volleyball players.

Key words: NCAA Division II women, vertical jumping characteristics, leg-resistance training

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Le but de cette étude était de déterminer l'effet de la formation de simple-jambe sur l'exécution verticale de saut pendant une transitoire simulée et du bloc à de divers temps de contact et d'approche dans les joueurs collégiaux de volleyball de femmes. Cinq joueurs de volleyball de femmes de la Division II entre les âges de 19-21 avec un poids moyen de 66.74+8.02 kilogrammes ont achevé l'étude. Les sujets ont été chargés de produire leur meilleur saut vertical pendant la transitoire et bloc pendant 2 épreuves à 4 fois différentes d'approche et de contact (temps sur la natte sautante). À partir de ces 8 épreuves, la moyenne des 2 tailles de saut et rapports de temps du vol verticaux les plus élevés time/contact ont été choisies pour l'anaylsis avant et après pendant 10 semaines de formation de résistance. Des différences dans l'exécution verticale de saut entre le prétest et posttest ont été également analysés du subjects' ; épreuves avec des temps semblables d'approche et de contact. Le subjects' ; le meilleur saut vertical a amélioré 4.27 centimètres sur la transitoire et 2.38 centimètres sur le bloc. Les rapports plus élevés du vol posttest time/contact n'étaient pas signficantly différents sur la transitoire essai de bloc de (p=0.48)and ((p=0.06) après formation. Les rapports améliorés de temps du vol time/contact au plus bas contact chronomètre la signification approchée sur la transitoire (p=0.026) et le bloc (p=0.04). La taille verticale de saut aux vitesses d'approche les plus rapides a augmenté l'amd de 3.30 centimètres 4.98 centimètres sur l'essai de transitoire et 4.27 centimètres sur l'essai de bloc aux plus bas temps de contact. Les résultats indiquent que la formation de résistance de simple-jambe est des méthodes efficaces pour améliorer l'exécution de saut de double-jambe sur la transitoire et à sauter dans des joueurs de volleyball de femmes de la Division II de NCAA.

INTRODUCTION

In the sport of volleyball, athletic conditioning programs are generally developed and initiated by coaches in order to improve performance, prevent injury, and gain the competitive edge. To achieve specificity of training, resistance exercises should closely resemble the mechanics and forces required to perform the necessary skills that occur on the court (Shondell & Reynaud, 2002). Performance is often dependent upon the athlete's jumping ability during offensive and defensive skills. In volleyball, a high percentage of the movement patterns are performed on a single leg. During the run-up and take-off phase of the spike or spike serve, a volleyball player rarely distributes the forces equally on both legs. These single-leg actions can occur from a single-leg stance or by transferring the forces from one leg to the other during a double-leg stance. For example, to complete the block, a player will land in preparation for take-off on one leg at a time and if the take-off is not exactly vertical, a double leg take-off will occur with unequal leg force production. Furthermore, the spike with a single-leg take-off is common among women players (Kortman, 2000). Tillman, Hass, Brunt, and Bennett (2004) determined that more than half of all defensive landings occur on one foot. Research has shown that the most frequent mechanism of injury in volleyball is a single-leg landing (Kovacs et al., 1997). To attain training specificity, it appears that resistance training programs designed to improve volleyball performance and prevent injury should include single-leg exercises.

REVIEW OF THE LITERATURE

Researchers have shown that training with strength and plyometric exercises is most effective to increase various measures of power performance (Wilson, Murphy, & Giorgi, 1996; Wilson, Newton, Murphy, & Humphries, 1993). Current knowledge on power improvement is based on findings from double-leg training programs. A recent study determined that varying contact time (time spent on the ground in preparation for a jump) (CT) had a greater effect on vertical jump performance than the variation of depth jump height (Walsh, Arampatzis, Schade, & Bruggemann, 2004). To improve performance in volleyball, it is not only important to improve vertical jump height, but also to improve jump performance during a fast approach to the jump location with a low CT. Previous studies have not considered that improved vertical jump height may have resulted from varied jumping techniques such as different contact times during the trials that produced the highest vertical jump.

Few studies have been conducted to determine the effects of single-leg training on improved sport skills. The analysis of vertical jump performance during varied approach and contact times in volleyball players is yet to be investigated after training. Therefore, the purpose of this study was to determine the effect of single-leg training on vertical jump performance during a simulated spike and block at various contact and approach times in collegiate women volleyball players.

METHODS AND PROCEDURES

Participants

Seven NCAA Division II women volleyball players volunteered to participate in the study. Due to injuries, five players completed the study. All participants signed written informed consent forms that were reviewed by the IRB of the University to ensure the participants were knowledgeable of the normal risks and procedures involved in the study. The participants were between the ages of 19-21 and had a mean weight of 66.74 ± 8.02 kg. This study began at the beginning of the off-season conditioning program. All of the participants had several years of resistance training experience during high school and 1-2 years of training at the college level.

Modified Single-leg Squat Test

Modified single-leg strength was measured by the use of the barbell free-weight squat. We previously found high reliability while measuring strength on the modified single-leg squat (McCurdy, Langford, Cline, Doscher, & Hoff, 2004). While performing the squat, participants placed the foot of their non-dominant leg on a support bar behind them to isolate the use of the dominant leg (Figure 1). The uninvolved foot was placed on the bar between

Figure 1. Modified Single-leg Squat

the metatarsals and toes. Prior to baseline testing, the participants were given a 2-week (4 training sessions) instructional period to learn proper technique with loads that approached their ability to complete 5 repetitions (5RM). Baseline tests were measured during week 3. A rest period of a minimum of 48 hours was given between each day of testing. Before all tests, participants were instructed to perform stretching and warm-up exercises individually to prevent injury during the test. During the strength assessment, each participant followed the procedures while supervised by an investigator. All participants were measured to attain a 90-degree angle between the femur and tibia while performing the squat test. The squat depth was marked and recorded by a measuring device designed by the researchers to record the depth of the squat for each repetition to ensure a 90-degree angle at the knee joint was achieved. The 3RM test was used to estimate the 1RM, which was determined using a 1RM prediction chart (Morales & Sobonya, 1996).

Block Test

Pre- and posttests were conducted to determine sport-specific tests of jumping performance before and after a 10-week training period. Before all tests, participants were instructed to perform warm-up exercises individually, followed by light stretching to prevent injury during the test. All warm-up sets were monitored and the protocol was posted in clear view of the participants.

The block test was designed to simulate the right-side block movement pattern that is executed during a game. Vertical jump performance was measured with a Kinematic Measurement System (Fitness Technology, Skye, Australia), which consisted of contact timing mats interfaced to a computer. Times were recorded in milliseconds and data were transferred to a computer for analysis. The kinematic measurement system, which utilizes flight time in the air to calculate vertical jump height, has been found to be a sensitive indicator of jumping performance by comparison of values derived from a force plate (Newton, Kraemer, & Hakkinen, 1999).

The timing mats were placed 1.85 m apart, which allowed all of the participants to reach the mat with normal footwork used to perform the block. The participants were instructed to start with their trail foot in contact with the starting mat and step with the lead leg toward the jumping area while turning to face the target mat. The trail leg crossed the lead leg to make first contact with the mat. As the lead leg initiated the double-leg stance in preparation for the jump, the participants performed a countermovement and completed the block. The approach time (AT) was determined by a timer that started as the trail foot was released from the starting mat and stopped when the trail foot made contact with the jumping mat. The amount of time that the participants' feet maintained contact with the mat was recorded as the CT. Flight time was determined as the amount of time that the participant remained in the air. The participants were instructed to perform a normal landing. A rest period of 1-2 minutes was allowed between trials.

After several practice trials, the participants were instructed to complete 2 trials at an estimated AT and CT that would produce the best vertical jump. The participants were given 2 trials at each speed to perform the block. Two trials were performed at a pace that the participants estimated to be 25% slower and 25% faster than the optimum pace. Feedback was provided to allow the participants to adjust their AT and CT in the following trials to produce a range of times for analysis of jumping performance. The participants were instructed to complete two trials at a maximum AT while jumping as fast as possible off of the mat. From these 8 trials, the average of the 2 highest vertical jump heights and flight time/contact time ratios (F/C) were selected for analysis. F/C is called reactive strength (Young, 1995). It is the ability to reverse the body's inertia quickly during the eccentric phase that is created during the landing and produce a powerful concentric contraction. Differences in vertical jump performance between the pre- and posttest were also analyzed from the participants' trials with similar AT and CT.

Spike Test

The spike test was designed to simulate the left-side spike movement pattern. The timing mats were placed 2.26 m apart with an approach angle of 60º from the net, which allowed all of the participants to reach the mat with their normal footwork. The participants started 1 step behind the starting mat. After stepping onto the starting mat with their right foot, the participants took 1 step with the left leg before making first contact with the target mat with the right foot. The time started when the right foot made contact with the starting mat and stopped with initial contact on the target mat. The procedures (warm-up, number of trials, and instructions) completed during the block test were followed to complete the spike test.

Training Protocol

The participants followed the single-leg resistance training program 3 days a week for 10 weeks. The single-leg exercises were implemented as core exercises to maximize strength and power improvement. The core exercises consisted of single-leg squats, lunges, step ups, and single-leg power cleans with dumbbells. The participants progressed during the 10-week training period from 3 sets of 10 repetitions at 65% of the participant's predicted 1RM to 6 sets of 5 repetitions at 87% on the strength exercises. Initial training loads on the lunges and step-ups were determined during the practice sessions. For the single-leg power cleans the participants progressed from 3 sets of 6 to 5 sets of 3 with a weight that the participant could complete with proper technique. Two days per week on the days that strength training did not take place, the participants completed single-leg plyometric drills. The women completed pogo jumps and countermovement vertical leaps each session while progressing from 3 sets of 5 to 3 sets of 15. The pogo jump was executed with minimal hip and knee flexion upon landing before rebounding vertically for maximum height without the use of the arm swing while the countermovement vertical leap was completed with a _ to _ squat. CT for these exercises, determined prior to training, ranged between 200 and 450 ms. Posttesting was conducted after the 10-week training period using the same protocols as previously described for the baseline tests.

Analysis

The data were analyzed with a Paired-Samples T Test. Following the Bonferroni procedure for performing multiple t-tests, alpha was set at $p = .01$ for the block and spike results. The data were analyzed to determine if statistical significant differences were found between pre-and posttest measures of the spike and block.

Results

The participants' best vertical jump height was analyzed to determine if a significantly different CT was performed between the pre- and posttest. Vertical jump height and the F/C were compared between the pre- and posttest during the trials that the participants approached the jump with their fastest time. Vertical jump performance was also analyzed during the trials that the participants jumped with the least CT. The participants' CT and AT were not significantly ($p < 0.05$) different between pre-and posttest measurements of jumping performance during the spike (Table 1) and block (Table 2) (see page 20). These times were compared to determine if jumping performance was analyzed while the participants performed similar jumping techniques during the pre- and posttest.

TABLE 1
Spike Contact and Approach Times

	Pretest	Posttest		
	Mean times (ms) ± SD	Mean times (ms) ± SD	Mean Diff ± SD	*P* value
Contact time during highest vertical jump height	329 ± 51.9	316.2 ± 74.9	13.4 ± 81.4	0.73
Lowest contact time	290 ± 55.8	294 ± 74.7	3.6 ± 34.7	0.83
Lowest approach time	447 ± 47.7	442 ± 29.0	5.6 ± 22.3	0.61

* Statistically significant ($p < 0.01$)

TABLE 2
Block Contact and Approach Times

	Pretest	Posttest		
	Mean times (ms) ± SD	Mean times (ms) ± SD	Mean Diff ± SD	*P* value
Contact time during highest vertical jump height	435 ± 48.2	389 ± 86.4	46.2 ± 48.1	0.10
Lowest contact time	389 ± 15.8	355.2 ± 50.0	34.2 ± 36.0	0.10
Lowest approach time	433 ± 34.1	419 ± 36.7	13.8 ± 40.6	0.49

* Statistically significant ($p < 0.01$)

The participants' best vertical jump height produced during the spike (Table 3) significantly increased after training. CT was similar for the pre- and posttest when the participants produced their best vertical jump height. The participants' best F/C slightly increased after training but was not significantly different. During the participants' fastest AT, vertical jump height approached significant improvement (3.30 cm) after training. Posttest F/C also increased above pretest scores but was not significantly different (p = 0.26). During the trials that the participants jumped with the least CT, the participants' 3.8 cm vertical jump height improvement after training approached significance (p = 0.12).

The participants' best vertical jump height produced during the block (Table 4) improved 2.38 cm but was not significantly different after training (p = 0.07). Although the mean CT was lower during the posttest, it was not significantly different than the mean CT during the pretest when the participants produced their best vertical jump height. The participants' best F/C approached (p = 0.06) significant improvement after training. During the participants' fastest AT, vertical jump height significantly increased above pretest scores (4.98 cm) while F/C approached significant improvement (p = 0.04) after training. During the participants' jump with the least CT, vertical jump height improvement (4.27 cm) approached significance (p = 0.08).

TABLE 3
Spike Tests

	Pretest	Posttest		
	Mean ± SD	Mean ± SD	Mean Diff ± SD	*P* value
Best vertical jump height (cm)	37.19 ± 1.96	41.45 ± 3.38	4.27 ± 1.93	0.01*
Best flight time/contact time ratio	1.90 ± 0.35	2.04 ± 0.66	0.14 ± 0.40	0.48
Vertical jump height at lowest approach time (cm)	32.31 ± 5.94	35.61 ± 5.56	3.30 ± 3.84	0.13
Flight time/contact time ratio at lowest approach time	1.40 ± 0.16	1.66 ± 0.55	0.26 ± 0.44	0.26
Vertical jump height at lowest contact time (cm)	35.15 ± 2.03	38.96 ± 3.45	3.81 ± 4.37	0.12

* Statistically significant ($p < 0.01$)

TABLE 4
Block Tests

	Pretest	Posttest		
	Mean + SD	Mean + SD	Mean Diff + SD	*P* value
Best vertical jump height (cm)	34.54 ± 4.45	36.93 ± 3.05	2.38 ± 2.18	0.07
Best flight time/contact time ratio	1.32 + 0.06	1.56 + 0.26	0.24 + 0.21	0.06
Vertical jump height at lowest approach time (cm)	29.92 ± 1.65	34.90 ± 4.19	4.98 ± 2.59	0.01*
Flight time/contact time ratio at lowest approach time	1.19 + 0.16	1.47 + 0.34	0.28 + 0.20	0.04
Vertical jump height at lowest contact time (cm)	30.89 ± 1.37	35.15 ± 4.29	4.27 ± 4.09	0.08

* Statistically significant ($p < 0.01$)

CONCLUSION

The results of this study revealed that vertical jump scores improved with single-leg resistance training. In a previous study, Newton, Kraemer, and Hakkinen (1999) found a significant improvement of 3.9 cm in the double-leg vertical jump in NCAA Division I male volleyball players (N=8) after double-leg weighted jump squat training. In our study, the participants' vertical jump height on the spike and block improved 4.27 cm and 2.38 cm, respectively. Similar results were reported by Fry, Kraemer, and Weseman (1991), who measured improved double-leg approach jump and reach performance in women collegiate volleyball players following double-leg weight training and plyometrics. The results of our study indicate that 10 weeks of single-leg training can effectively improve vertical jump height on the spike and block in female college volleyball players.

In this study, jumping performance was analyzed at a similar CT and AT after training. Walsh, Arampatzis, Schade, and Bruggemann (2004) found that the highest double-leg vertical jumps occurred at similar CT (mean contact 161-167 ms) from drop jumps at 20, 40, and 60 cm. Walsh et al. (2004) concluded that variations in CT should be analyzed to determine improved performance after training. Without measurement of the CT, improved vertical jump height after training could be a result of a difference in CT. The results in our study showed that when the participants produced their best vertical jump height for the spike and the block, CT (ranged between 316 ms and 345 ms) was similar during pre- and posttest evaluation. These CT scores were similar to the CT completed during the plyometric exercises. CT associated with the best vertical jumps were longer (spike mean CT 329 ms and block mean CT 435 ms) than the CT found by Walsh et al. and was likely due to a difference in footwork among the spike, block and drop jump.

During the fastest AT, the vertical jump height during the spike approached significant improvement, while the block vertical scores significantly improved. In many cases during a game, a player must jump for maximum height immediately after moving quickly to the spot of the jump. Vertical jump height also improved during the spike (3.81 cm) and block (4.27 cm) jumps with the lowest CT. The data suggest that single-leg weight and plyometric training effectively improves double-leg jumping performance with a fast approach speed and a short CT, which takes place with a landing and countermovement in preparation for a jump.

F/C increased during the fastest AT but was not significantly different for the spike ($p = 0.26$) and block ($p = 0.04$) after training. Whereas, the best F/C, independent of AT, also increased after training for both the spike and the block with the block scores approaching significance ($p = 0.06$). With a larger sample size, the observed improvements would likely be significant. More research is needed to determine if F/C improves after training. Further research is needed to compare the effects of single- and double-leg training programs on sport specific single- and double-leg jumps.

IMPLICATIONS FOR COACHING

The spike and block jumps that were analyzed use a one-leg approach and landing in preparation for a double-leg take-off. The findings suggest that single-leg training will improve double-leg jump performance. To design sport-specific resistance training programs for women volleyball players, the data suggest that coaches should include single-leg exercises. More research is needed to determine the amount of emphasis that should be placed upon single-leg exercises within the training program. The principle of specificity implies that resistance training programs should resemble the single-leg movement patterns that occur in volleyball.

This study analyzed best jump performance and jump performance with similar AT and CT. During many cases in a volleyball game, maximum jumps must be made soon after landing from a previous jump or after a fast approach to the spot of the jump. This would require jumps with less CT with the court surface in order to be more proficient (Walsh, Arampatzis, Schade, & Bruggemann, 2004). The results from this study suggest that after single-leg resistance training, spike and block vertical jump scores during the least AT and CT can be improved. Although several measures of jump performance were not significant, the observed differences are noteworthy for elite volleyball players who already possess a high level of performance. Further research is needed to determine the specific single-leg resistance exercise prescription that should be included in the training program for volleyball players to improve performance on the court.

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BIOS NEEDED

Changes in Strength Parameters During Twelve Competitive Weeks in Top Volleyball Players

M.C. Marques, M.D., University Castilla-la-Mancha, Toledo, Spain
J.J. González-Badillo, Ph.D., Spanish Olympic Committee
P. Cunha, Ph.D.; L. Resende, Ph.D.; P. Domingos, Ph.D.; M. Santos, Ph.D.
"Castêlo da Maia" Elite Team Volleyball

Competitive volleyball requires a substantial muscular strength and power. To date, few studies have investigated the interaction between strength programs and volleyball regular training immediately after the preparatory period in top volleyball players (TVPs). Therefore, 11 elite male TVPs (average age: 25.67 range 20-30) submitted to a 12-week strength training program apart from normal technical/tactical practice sessions (3-4 hours per day) and competitions. The overall sample was tested on 2 occasions for maximum strength (bench press and half squat) and explosive strength (jumping and throwing). The first testing session was completed at the end of a preparatory period ST (5 weeks) to ensure that all athletes would be in a state of good overall condition. The results suggest that elite TVPs can optimise their performance over 12 weeks of ST during the competition season.

Key words: top volleyball athletes, strength parameters

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INTRODUCTION

Success in team sports, particularly volleyball, is determined by a developmental level and structure of a large number of specific abilities, attributes and the net of technical-tactical knowledge of athletes. Hereditary or acquired anthropological characteristics of a male player who plays in a particular position on a volleyball team may either enable or interfere with accomplishment of a desirable level of situation-related effectiveness in competition. Therefore, gaining an insight into the status of these attributes becomes ever more important in top-quality volleyball because such information facilitates programming and control of the training process effects. The design of a strength-training program is based on testing the most important strength qualities.

The purpose of the initial testing was to determine the level of work capacity in players, i.e. their trainability, and their potential for the highest sporting achievements planned in a particular competition they are preparing for. The obtained indicators are starting points in the process of training programming and then come analysis and comparison to the standards of the top-level preparation model.

It will be interesting to determine if and to what degree explosive strength magnitude change during the course of a high-level team volleyball competition period (12 weeks). This is crucial because a primary goal of in-season competition is to optimize strength parameters.

METHODS

Participants

The sample was comprised of 11 elite male TVPs (average age: 25.67, range 20-30; Table 1) including 5 international Portuguese

Table 1

Mean (±SD) results of the selected characteristics of the participants.

Variables	(Means ± SD)
Age (yr.)	25.67 ±2.69
Height (cm)	192.0±7.12
Body Mass (kg)	87.56±8.08
Arm sample (cm)	193.2.6±8.2
Training years	14.21± 2.01

players and one Brazilian international player (champions of the Portuguese First League, the Portuguese Cup winners and a Top Teams Cup European Final). The overall sample of this study was fully informed of all possible risks and stresses associated with the project and signed consent forms prior to participation. The study was conducted according to the declaration of Helsinki and was approved by the Ethics Committee of the department responsible. Training and all testing were performed during the competitive season.

Procedures

The overall sample was tested on 2 occasions (before training: Before; after 12 weeks of training; Post) for maximum strength (bench press and half squat) and explosive strength (jumping and throwing). Apart from normal technical/tactical practice sessions (3-4 hours per day) and competitions, all underwent 12 weeks of strength-training (ST). All testing was completed at the end of a preparatory period ST (5 weeks) to ensure that all athletes would be in a state of good overall condition. This entailed weight training 3-4 times per week with media/low intensity. This included 2 strength exercises (bench press and half squat); and another four tree power exercises such as countermovement jump, clean, medicine ball throwing, and sprinting. Consequently, all the athletes were in their peak condition and were familiar with all the testing exercises, which they had been performing regularly as part of training.

Vertical jump height was measured through the CMJ (countermovement jump) test described by Bosco (1994). With a preparatory countermovement, each participant started from an erect standing position and the end of the concentric phase corresponded to a full leg extension: 180º. The protocol required the performance of 3 jumps, each followed by 2 minutes of rest. An average of the 2 best jumps was taken. Subsequently, all performed trials of CMJ weighted with 10, 20 and 30 kilograms (CMJ10kg, CMJ20kg and CMJ30kg) on a shoulder bar. The CMJ showed an ICC (intraclass correlation coefficient) of 0.95 and a CV (intraclass correlation coefficient) of 4.7%. The CMJ with additional weights showed an ICC of 0.97 in CMJ10kg, 0.98 in CMJ20kg and 0.97 in CMJ30kg, respectively. These tests registered a CV of 2.2%, 3.4% and 5.4%, respectively, in CMJ10kg, in CMJ20kg and in CMJ30kg. All tests were measured on a trigonometric carpet (Ergojump Digitime 1000, Digest Finland).

For throwing performance, each participant held the medicine ball in both hands with arms relaxed and then lift the ball over their head quickly and as far as possible. All TVPs then executed five trials of throws with a medicine ball (3kg). A 1-minute interval separated each trial. An average of the best 4 shots was taken. The distance of the throw was recorded to the closest one-quarter inch. The BTd (ball throwing distance) showed an ICC of 0.83 and a CV of 4.2%.

The maximal strength tests for the upper and lower muscles were carried out using 4-rep maximum bench press (4RMBP) and 4-rep maximum half squats (4RMHS). In 4RMBP, each participant was instructed to perform a concentric-eccentric action from the starting position, maintaining the shoulders close to a 90º abduction position in eccentric phase to ensure consistency of shoulder and elbow joints throughout the movement. Each participant started with a weight of 40kg, this being increased by increments of 5kg until the player was unable to reach full arm extension. The last bearable load was determined as 4RM. The rest time between the actions was 3 minutes. In the 4RMHS, the shoulders were in contact with a bar and the starting position knee angle was set at 180º (full leg extension). Each player started with identical weights of 100kg, performing on command a series of 4 half squats. Subsequently, the weight was increased by 10kg increments until the participant was unable to reach the full extension of the legs. The last bearable load was determined as being 4RM. Twenty-minute rest intervals separated the 4RMBP and 4RMHS tests. The 4RMBP showed an ICC of 0.98 and a CV of 9.7%. The 4RMHS reported an ICC of 0.98 and a CV of 4.2%.

Ordinary statistical methods were used for the calculation of average and standard deviations. Paired samples test analysis was used to assess the presence gains or losses. Measurement reliability was assessed in two trials separated by 5 days in all TVPs. The Pearson correlation coefficient was calculated and the level accepted for statistical significance was $p<0.05$.

The ST program consisted of 2 sessions per week over 12 weeks (Tables 2a and 2b). The main ST exercises were, respectively, the bench press and half squat, plus jumping and throwing. Participants performed 3 sets of 3-6 reps with a load of 50-80% 4RMBP; and 3 sets of 3-6 reps with a load of 30-75% of 4RMHS. On completion, TVPs then performed 3 explosive strength exercises: 1. vertical jumps into a box; 2. vertical jumps with additional weights (3 sets of 5 reps: loads varied between 10kg to 40kg); 3. throwing medicine ball (3 sets of 10 reps. with a 3kg medicine ball). Rests of 2 minutes were permitted between sets and between categories.

RESULTS AND DISCUSSION

The throw distance and jumping height results are presented in Table 3. TVPs experienced significant improvements in BTd (9.7%; $p<0.003$). The results also showed significant gains in attained vertical jump height calculated in CMJ20kg (9.5%; $p<0.008$) and CMJ30kg (12.7%; $p<0.008$) during the course of the research (Table 3), except for the CMJ and for the CMJ10kg.

Table 3

Mean (+SD) results in centimetres of different parameters:

countermovement jump height (CMJ), CMJ with different loads (CMJ10kg, CMJ20kg and CM30kg) – before (T1) and post (T2:0-12 weeks).

TESTS (n=11)	T1 – Bef	T2 – Post (0-12 weeks)	Significance
Variables	Mean ± SD	Mean ± SD	T1-T2
BTd	11.43+1.13	12.67+0.80	p <0.003
CMJ	46.32+4.69	49.06+5.87	ns
CMJ10kg	36.16±4.6	40.01±5.4	ns
CMJ20kg	30.94±3.94	34.28±5.3	p <0.008
CMJ30kg	26.7±4.32	30.10±5.4	p <0.008

Legend: ns - no significant difference

Table 2a

Strength training programs between week 0 and week 6.

Exercises	**Session 1**	**Session 2**	**Session 3**	**Session 4**	**Session 5**	**Session 6**
_ Squat (1)	30: 3x6	30: 3x6	40: 3x6	40: 3x6	45: 3x6	45: 3x6
CMJ with additional load	3x5:10kg	3x5:10kg	3x5:10kg	3x5:10kg	3x5:20kg	3x5:20kg
CMJ into a box	5x6	5x6	5x6	5x6	5x6	5x6
Bench press (2)	50: 3x6	50: 3x6	50: 3x6	50: 3x6	60: 3x6	60: 3x6
Ball throwing	3x10:3kg	3x10:3kg	3x10:3kg	3x10:3kg	3x10:3kg	3x10:3kg
Exercises	**Session 7**	**Session 8**	**Session 9**	**Session 10**	**Session 11**	**Session 12**
_ Squat (1)	50: 3x6	50: 3x6	55: 3x6	55: 3x6	55: 3x6	60: 3x6
CMJ with additional load	3x5:30kg	3x5:30kg	3x5:30kg	3x5:30kg	3x5:30kg	3x5:35kg
CMJ into a box	5x6	5x6	5x6	5x6	5x6	5x6
Bench press (2)	60: 3x6	70: 3x6	70: 3x6	70: 3x6	75: 3x4	75: 3x4
Ball throwing	3x10:3kg	3x10:3kg	3x10:3kg	3x10:3kg	3x10:3kg	3x10:3kg

Legend: (1): Example: 50: 3x6: 3 sets of 6 reps with 50 percent of 4RM1IS;

(2): Example: 60: 3x6: 3 sets of 6 reps with 60 percent of 4RMBP

Table 2b

Strength training programs between week 7 and week 12.

Exercises	**Session 13**	**Session 14**	**Session 15**	**Session 16**	**Session 17**	**Session 18**
_ Squat (1)	65: 3x6	65: 3x6	65: 3x6	70: 3x5	70: 3x5	70: 3x5
CMJ with additional load	3x5:35kg	3x5:35kg	3x4:40kg	3x4:40kg	3x4:40kg	3x4:40kg
CMJ into a box	5x6	5x6	5x6	5x6	5x6	5x6
Bench press (2)	75: 3x6	75: 3x6	75: 3x6	75: 3x6	80: 3x3	80: 3x3
Ball throwing	3x10:3kg	3x10:3kg	3x10:3kg	3x10:3kg	3x10:3kg	3x10:3kg
Exercises	**Session 20**	**Session 21**	**Session 22**	**Session 23**	**Session 24**	**Session 25**
_ Squat (1)	70: 3x5	70: 3x5	75: 3x4	75: 3x4	60: 3x6	Testing
CMJ with additional load	3x4:40kg	3x4:40kg	3x4:40kg	3x4:40kg	3x5:35kg	
CMJ into a box	5x6	5x6	5x6	5x6	5x6	
Bench press (2)	80: 3x3	80: 3x4	80: 3x4	80: 3x4	70: 3x6	
Ball throwing	3x10:3kg	3x10:3kg	3x10:3kg	3x10:3kg	3x10:3kg	

Legend: (1): Example: 50: 3x6: 3 sets of 6 reps with 50 percent of 4RMHS;

(2): Example: 60: 3x6: 3 sets of 6 reps with 60 percent of 4RMBP

The maximal strength results are presented in Table 4. The results showed no significant gains in 4RMBP and 4RMHS during the experimental study.

Table 4

Mean (±SD) results in kilograms of different parameters:

supine bench press (4RMBP), half squat (4RMHS) - before (T1) and post (T2:0-12 weeks).

TESTS (n=11)	T1 – Bef	T3 – Post (0-12 weeks)	Significance
Variables	Mean ± SD	Mean ± SD	T1-T2
4RMBP	78.89±12.94	85.56±12.91	ns
4RMHS	156.18±22.27	168.89±28.48	ns

Legend: ns - no significant difference

The correlation results are outlined in Table 5. No correlation was found between 4RMBP and BTd during 12 weeks of ST. The highest correlation was observed between 4RMHS and CMJ (0.83; $p<0.009$).

Most of the 7 variable numerical differences were ob-tained in achievements between the first and the second measurement. The fact that in certain variables these differences, expressed as descriptive parameters, are noticeably high, even at this level of interpretation seems to suggesting that statistical significance of effects was obtained. The level of the test results achieved suggests the high quality of selection of the top-quality volleyball players, comparable to the best European players.

It is well-known that progressive overload is necessary for increasing muscular strength and that for adaptations to occur, a stimulus exceeding a previous stimulus needs to be applied during a resistance-training program (Carpinelli & Otto, 1998; Rhea, Alvar, Burkett & Ball, 2003; Winett, Wojcik, Fox, Herbert, Blevins & Carpinelli, 2003). However, it is also conceivable that when a given threshold level of strength training intensity has been reached in experienced resistance-trained participants, the appropriate physiological adaptations may be optimized and the performance of additional resistance training intensity provides no further benefits (Fry & Kraemer, 1997; Fry, Kraemer, Van Borselen, Lynch, Marsit, Roy, Triplett, & Knuttgen, 1994; Fry, Webber, Weiss, M.D. Fry, & Y. Li, 2000). Conceptually, this would suggest that an optimal training intensity would reflect the optimal amount of training intensity eliciting maximal performance enhancements and that performance could be also compromised if an intensity threshold were surpassed.

Throughout the years, several studies have systematically supported the importance of ST in different sports. Several researchers have

Table 5

Correlations between: strength vs. throwing distance, strength vs. jump height - before (T1) and post 12 weeks (T2).

TESTS (n=11)	T1-T2	
Variables	r	*p*
4RMBP vs. BTd	*None*	
4RMHS vs. CMJ	0.83	p<0.009
4RMHS vs. CMJ10kg	0.74	p<0.024
4RMHS vs. CMJ20kg	0.77	p<0.015
4RMHS vs. CMJ30kg	0.78	p<0.012

Legend: ns - no significant difference

employed different methodological approaches to investigate the efficacy of ST programs in distinct physical demands. Some applied heavy ST programs (Häkkinen & Komi, 1985b), whereas others used a combination of heavy and explosive exercises (Adams, O'Shea, O'Shea, & Climstein, 1992).

The effect of various ST programs on vertical jump ability has been researched extensively (Adams, O'Shea, O'Shea, & Climstein, 1992; Häkkinen & Komi, 1985a; Häkkinen & Komi, 1985b; Wilson, Newton, Murphy, & Humphries, 1993). Hakkinen and Komi (10) amongst others (Adams, O'Shea, O'Shea, & Climstein, 1992; Wilson, Newton, Murphy, & Humphries, 1993), found significant improvements in jumping ability over 24 weeks of heavy ST. A special combination of loaded squat jumps and specific plyometric jumps resulted in significant improvements in CMJ height after a heavy ST period (Häkkinen & Komi, 1985b). However, the degree of general strength gained through squat training does not seem to affect the degree of change in jumping performance. Alén, et al (1994) claimed to observe no change in jumping performance in well-trained athletes following 24 weeks of heavy squat training, while noticing a large improvement in 1RM squat strength. Baker et al. (1994) add that in trained athletes, the relation between changes in 1RM squat performance and vertical jump consequent upon training was also nonsignificant ($r=0.11$). In contrast, the present investigation identified significant correlations ($r=0.83$; $p<0.009$) between 4RMHS and CMJ. Since the development of inter-muscular co-ordination is basically a function of skill training (Baker, 1996), it can only be maximized by using loads that resemble the skill in terms of movement, speed and pattern, so that technique is not altered drastically. A general exercise for the leg muscles (squat) using a heavy load is relatively more effective for development of intra-muscular co-ordination, whereas the use of loaded-squat jumps is more effective for developing inter-muscular co-ordination (Baker, 1996; Wilson, Newton, Murphy, & Humphries, 1993). This could explain part of the improvements noticed in the present data.

In both 1RMBP and 4RMPS, THPs did not experience great improvements in strength performance. Since all participants were top athletes, players might well have reached their strength ceiling. Another reason can be attributed to the previous five weeks of ST. We believed that players reached their maximum levels during this period. Therefore, the improvements observed in the other variables could be related to distinct factors. For example, after a heavy ST period, important neuromuscular adaptations occur (Sale, 1992, Schmidtbleicher, 1992), implying a higher recruitment of motor units and an increased firing rate of motor neurons (Schmidtbleicher & Buerhle, 1987; Zatsiorsky, 1995), especially in trained athletes (Zatsiorsky, 1995). Moreover, this suggests that other factors were responsible for significant improvements observed in BTd, since there was no relationship between upper-body power test and 4RMBP.

In this investigation, 2 weeks of strength training leads to great improvements in jumping ability and throwing distance. These conclusions should be interpreted within the contexts of the study and its sample of experienced players. Future research should involve the effect of ST on performance in elite TVPs.

IMPLICATIONS FOR COACHING

The present findings suggest that ST could influence TVPs performance, especially in jumping ability and throwing ball distance. This exposure to moderate high intensities strength exercises may then lead to contractile changes occurring within the muscle(s), tending the muscle toward more inherently powerful contractions. As a result, this could lead to an increased ability to manifest maximal strength into maximal power and presumably into improved power during sport-specific movement patterns.

The primary limitation of this study is not having a control group. However, we can speculate the strength gains were probably due to the addition of the ST program since all participants were in a peak condition at the beginning of the study. The overall sample play all the transition period (beach volleyball and summer volleyball leagues) and each participant performed an ST program during this time in order to prevent injuries and detraining.

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Effect of the Setter's Position on the Block in Volleyball

Jose Manuel Palao, Ph.D., Catholic University of St. Anthony (Murcia, Spain)
Jose Antonio Santos, Ph.D., and Aurelio Ureña, Ph.D., University of Granada (Spain)

This investigation determined the effect of the setter's position on block performance and the way the block is executed (number of players in block, court zone, and ball contact on block). A total of 4,968 actions of 33 men's matches and 2,450 actions of 23 women's matches of the 2000 Olympic Games were analyzed. It was determined that block performance in relation to setter's position tends to be balanced, although in counter attack the setter's position affects the number of players in the block.

Key words: volleyball, rotation, setter, performance, block

Cette recherche a étudié l'effet de la position de setter's sur l'exécution de bloc et la manière le bloc est exécutée (nombre de joueurs en bloc, zone de cour, et contact de boule sur le bloc). Un total de 4968 actions de 33 allumettes masculines et 2450 actions de 23 allumettes femelles des 2000 jeux olympiques ont été analysés. Les résultats ont prouvé que l'exécution de bloc par rapport à la position de setter's tend à être équilibrée, bien que dans la contre- attaque la position de setter's affecte le nombre de joueurs dans le bloc.

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REVIEW OF THE LITERATURE

One of the characteristics of volleyball that distinguishes it from the rest of the team sports (Fröhner, 1988; Beal, 1989; Baacke, 1994) is that all players have to pass through all positions of the court (article 7.6: rotation rule), which changes the skills that they do in function of their position on the court (article 7.4: position rule, and article 14: attack hit). Santos (1992) indicates that each team really has 6 "teams" that correspond with the 6 rotations, because in each rotation the positions, functions, and relations between players are different. Furthermore, these functions change in side out and in defense. However, rotations can be grouped in relation to the position of the setter on the court (Santos, 1992). Therefore, 2 phases can be differentiated in the game: front setter and back setter. These phases affect the technical skills that occur with jumping close to the net, in spike and in block. The reasons for these alterations include (Santos, 1992): a) Number of spikers in the front court (three when the setter is in back and two when the setter is in front). This affects the performance of the spike, so when the team has only 2 front spikers in high- level teams, the performance is reduced (Murphy & Over, 1989), while in low-level teams the performance increases, because they use simple systems and use the best spikers (Santos, 1992); b) Typical weakness of the setter in blocking, which provokes a decrease in the performance of the collective block (Santos, 1992). Teams usually search out this weakness in the blockers (Herrera, Ramos, Mireya and Hilaron, 1989; Grzadziel, 1991).

The importance of the balance between spike and block on the result of the game is something researched and verified (Beal & Murphy, 1989; Eom, 1989; Eom & Schutz, 1992; Díaz, 1996; Grgantov, Dizdar & Jankovic, 1998; Schleuder, 1998). While the effect of the spike in the game has been constant, the effect of the block has changed in the last few years. In the 1988 Olympic Games, the performance of the block was fundamental for team performance (Over, 1990; Baacke, 1990; Coleman, 1992), but in the 1992 Olympic Games, the correlation of this skill with team performance was weak (Díaz, 1996), because of the increase in spike capacity of the team (Zimmerman, 1993). In the 1994 World Championships and the 1996 Olympic Games, the block again increased performance (Alberda, 1995; Fröhner and Murphy, 1995; Murphy, 1995; Fröhner and Zimmermann, 1996; Fröhner, 1997). However, the inclusion of the libero looks to have reduced block performance in the 1998 World Championships (Zimmermann, 1999).

In this study, there are 2 important limitations: one is the reduced research data that exists on the analysis of spike performance by rotations (although it is common practice for teams in competition to do it), and the other is the rule changes made by the Fédération Internationale de Volleyball (FIVB, 1999), as they have changed the structure of the game (score system-rally point system; and the creation of the new dig specialist, the "libero").

The score system change has modified the way to earn points (Zhang, 2000). The side-out phase has changed from preventing the serving team from scoring to being the principal way of getting points (Ahrabi-Fard & Hensley, 1995; Zimmerman, 1999; Zhang, 2000). This, in theory, has increased the importance of the spike after reception and has reduced the importance of the block and attack after digging to earn points.

The purpose of this investigation was to determine the differences in the performance and execution of the block in rotations where the setter is in front and rotations where the setter is in back in function of gender and rally phase.

METHOD

A total of 4,968 actions from 33 male matches and 2,450 actions from 23 female matches of the 2000 Olympics Games in Sydney were analyzed in this descriptive pre-experimental study. The variables registered were block performance, number of players in block (0, 1, 2 or 3 players), zone of the court where block is done, whether there was ball contact on block, rally phase (side-out defense and counter-attack defense), setter's position of both

teams (front and back) and gender.

Block performance was evaluated in relation to the success and options that block gave to the opposite team. We utilized the statistic system of the Fédération Internationale de Volleyball (FIVB), which distinguishes 5 levels to categorize the performance of the block:

1) Error (0). Failed block or block that did not allow the option to continue (point for the opponent).

2) Maximum opponent attack options or no attack options (1). Block was easily defended and allowed the opponent to counter-attack with all attack options or block did not contact the ball (maximum opponent attack options); or ball was defended after contacting the block but opponent could not attack, they simply passed the ball (No attack options).

3) Opponent attack options or team attack options (2). Block was defended and opponent counter-attacked with some attack options (opponent attack options); or block contacted the ball and the team in defense counter-attacked with some attack options (team attack options).

4) No opponent attack options or maximum team attack options (3). Block was defended but opponent could not attack, they simply passed the ball (no opponent attack options); or block contacted the ball and the team in defense counter-attacked with all attack options (Maximum team attack options).

5) Point (4). Block was a success.

Note: A coefficient of the block performance is calculated (sum of attempts by category multiplied by value of the category and divided by total attempts).

The observation was done by 10 observers trained during 12 sessions of 2 hours each following the criteria established by Anguera (1991, 1993), Behar (1993) and Anguera, Blanco, Losada and Hernández (2000). After the training and during the analysis, the inter-observers' and intra-observers' reliability percentages of the studied variables were calculated (all observers had an inter-observers' reliability of more than 85%). The descriptive and inferential analysis of the data was done using the SPSSx program (Chi-Square Test and likelihood ratio) with a level of statistic significance of $p<.05$.

RESULTS AND DISCUSSION

The results show that both in male and in female, the block performance between rotations where setter was in back and was in front were balanced (Table 1), so the theoretical debility of the setter in block (Santos, 1992) has not been found because of an increase in the setter´s block performance and/or because the teams have found a way to balance the block line.

With respect to the number of players blocking (Table 2), the results show a significant increase in triple blocks and a significant reduction in single blocks when the setter is in back. These differences occur in the less predictable game phase (counter-attack defense), although in defense of side-out it does not occur.

Table 2. Effect of setter's position on number of players in block in the (data are expressed in percent)

				Number
Gender	**Phase**	**Setter**	**Zero players**	**1 player**
Male	**Defense side-out**	**Front**	3,3	26,7
		Back	3,8	27,6
	Defense Counter-attacks	**Front**	7,0	20,8 **
		Back	6,7	14,8 **
	Total	**Front**	4,6	24,6
		Back	4,9	22,9
Female	**Defense side-out**	**Front**	3,1	17,7
		Back	1,8	18,6
	Defense Counter-attacks	**Front**	5,1	21,7 *
		Back	7,8	17,0 *
	Total	**Front**	4,1	19,6
		Back	4,3	17,9

Legend: * Chi-Square Test: statistic significance of p<.006 / ** Chi-Sq p<.000

In relation to the block zone (Table 3), the results do not show significant differences between the zones where the block is done, which indicates that the distribution of attack does not change in

Table 3. Effect of setter's position on block zone in the 2000 Olym expressed in percent)

Gender	**Phase**	**Setter**	**Zone 2**
Male	**Defense side-out**	**Front**	37,6
		Back	35,4
	Defense Counter-attacks	**Front**	38,7
		Back	41,4
	Total	**Front**	38,0
		Back	37,6
Female	**Defense side-out**	**Front**	37,6
		Back	35,4
	Defense Counter-attacks	**Front**	48,3
		Back	48,0
	Total	**Front**	45,4
		Back	44,3

Table 1. Effect of setter's position on block performance in 2000 Olympic Games in Sydney (data are expressed in percent)

			Block performance					
Gender	**Phase**	**Setter**	**Error**	**Max Options**	**Options**	**No options**	**Point**	**Coefficient**
Male	**Defense side-out**	**Front**	21,2	57,3	9,0	4,7	7,8	1,21
		Back	23,6	54,4	9,9	3,7	8,5	1,19
	Defense Counter-attacks	**Front**	24,2	49,0	11,8	3,9	11,1	1,29
		Back	25,8	46,5	10,5	5,5	11,7	1,31
	Total	**Front**	22,3	54,3	10,0	4,4	9,0	1,24
		Back	24,4	51,5	10,1	4,3	9,6	1,23
Female	**Defense side-out**	**Front**	21,9	53,2	10,8	6,2	7,9	1,25
		Back	18,1	55,0	12,9	5,1	8,9	1,32
	Defense Counter-attacks	**Front**	23,4	53,8 *	11,4	4,2	7,3	1,18
		Back	24,3	48,6 *	13,6	4,7	8,8	1,25
	Total	**Front**	22,6	53,5	11,1	5,3	7,6	1,22
		Back	20,8	52,2	13,2	4,9	8,8	1,29

Legend: * Chi-Square Test: statistic significance of p<.048

With respect to ball contact on the block (Table 4), the results indicate that in the female game in counter-attack defense, when the setter is in front line blocking, there is a significant increase in block contact. The cause of this increase in these situations is that the spiker looks for more block contact (Herrera et al., 1989; Grzadziel, 1991), although this does not affect the performance of the block (see Table 1).

2000 Olympic Games in Sydney

of players in block	
2 players	3 players
62,6	7,4
62,1	6,5
58,4	13,8 **
60,2	18,3 **
61,1	9,7
61,4	10,8
73,0	6,2
71,4	8,2
67,4	5,8 *
67,1	8,1 *
70,4	6,0
69,6	8,2

uare Test: statistic significance of

CONCLUSION

The following conclusion has been derived:

a) Block performance with respect to setter's position tended toward equality and balance in the 2000 Olympic Games in Sydney.

b) Setter's position affects the number of players blocking in counter-attack defense.

c) In women's volleyball, the setter's position increases contact with the ball in counter-attack defense.

d) Performance and execution of the block change in the different phases of the game: side-out defense and counter-attack defense. Therefore, their organization and training should be done independently and in function of their characteristics.

npic Games in Sydney (data are

Block zone	
Zone 3	Zone 4
31,9	30,5
33,2	31,4
26,6	34,7
24,8	33,9
30,0	32,0
30,1	32,3
31,9	30,5
33,2	31,4
22,5	29,2
23,4	28,6
24,4	30,3
25,7	30,1

IMPLICATIONS FOR COACHING

The results of block performance show that the spike is superior to the block in performance (2 errors and 0.8-0.9 points for every 10 blocks accomplished). Further, blocks that contact with the ball are few (5 contacts for every 10 blocks achieved). Therefore, coaches must remember that reduced block efficiency occurs even at the Olympic level. The block is one of the most difficult skills for players to learn, and low performance and few contacts with the ball do not help to get a successful acquisition of this skill. It is important that players are provided correct feedback about blocking and remind players that neutralizing the ball is only one of the objectives of the block. A block even without contacting the ball can be successful because it affects the direction and spike execution.

As a coach, another important objective to establish is the utilization of the double block or triple block against every single attack (in the studied actions this happened in 71% of men's attacks and 76% of women's attacks). The increase in the use of the triple block in counter-attack, as observed in the Olympic level (16% for men and 7% for women), should be adapted to players and competition levels and should be practiced by teams before being applied in games.

With respect to the setter's position, the results do not show the theoretical debility of the setter in the block. The balance tends to be achieved by the reduction of the setter's implication around the net (only blocking in zone 2) and the tactical re-adaptation of the rest of the blockers in the net. However, the spikers continued looking for the setters with their spikes. Therefore, the work of the setter in blocking should be orientated to static blocking with hands and arms well located to avoid block-out, and the team should define block tactics in both game situations (setter in front and setter in back) and practice them.

The values of coefficients, ratios of success and error, number of players in block, etc., must be used as a reference and adapted to the competition level. Players should practice the block, keeping in consideration the differences between the rally phases (defense side-out and counter-attack-defense) and differences in gender.

Table 4. Effect of setter's position on ball contact in block in the 2000 Olympic Games in Sydney (data are expressed in percent)

			Ball contact in block	
Gender	Phase	Setter	Contact	No contact
Male	Defense side-out	Front	57,1	42,9
		Back	54,4	45,6
	Defense Counter-attacks	Front	48,8	51,2
		Back	47,6	52,4
	Total	Front	54,2	45,8
		Back	52,0	48,0
Female	Defense side-out	Front	51,5	48,5
		Back	52,2	47,8
	Defense Counter-attacks	Front	54,3 *	45,7*
		Back	49,0*	51,0 *
	Total	Front	52,8	47,2
		Back	50,9	49,1

Legend: * Chi-Square Test: statistic significance of p<.042

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José Manuel Palao, Ph.D., is a professor on the faculty of Health, Physical Activity and Sport at the Catholic University of St. Anthony (Murcia, Spain). He was head coach of the male professional team at the University of Granada (1999-2000) and currently is coaching an under-16 team in the female professional club Voley Murcia. jmpalao@pdi.ucam.edu

José Antonio Santos, Ph.D., is a professor on the faculty of Physical Activity and Sport at the University of Granada (Spain). He is an instructor of the International Volleyball Federation (FIVB, 1994-2004). He was a member of the Development Commission of the FIVB (1994-2001). He was head coach of the female Spanish national team (1989-1991) and currently is coaching the male professional team at the University of Granada (1997-1999; 2002-present). jasantos@ugr.es

Aurelio Ureña, Ph.D., is a professor on the faculty of Physical Activity and Sport at the University of Granada (Spain). He was head coach of the female professional team at the University of Granada (1994-1997; 2000-2001). Currently, he is head coach of the female Spanish national team (2001-present). aurena@ugr.es

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Determination of Risk Factors for Low Back Pain in Female Adolescent Volleyball Players

Dennis L. Nosco, Ph.D., Kim Carpenter, D.C., John Zhang, M.D., Ph.D.
Contribution from Logan College of Chiropractic, Chesterfield, Mo. (USA)

Low back pain (LBP) is prevalent among volleyball players and is a significant problem among female adolescents. This study attempted to identify risk factors for LBP in female adolescent volleyball players (FAVBP) playing highly-competitive, year-round volleyball. In an IRB-approved study, 20 FAVBP (10 reporting LBP and 10 age-matched controls) 13-17 years old were recruited via local volleyball newsletter advertising. Indicators of adolescent female LBP identified from literature reports were combined with physical and volleyball-specific skill measurements to identify participant demographics, volleyball and other sports participation, medical history (including scoliosis and LBP history), isolated muscle group strength, flexibility, spiking and serving technique and known risk factors for adolescent LBP including: growth spurts, familial LBP history, car accident history, excessive weight training, lack of sleep, physical activity, menstrual cycle onset, excessive TV or computer use and jobs after school. Data was analyzed descriptively and using correlative statistics (paired t, Chi Squared, Wilcoxon Rank Sum and Fischer's Exact tests) for comparisons between groups. Significance was set at $p<0.05$. Only four factors attained or came close to attaining significant correlation with LBP in correlative analyses: active hip flexibility asymmetry ($p=0.0036$, Wilcoxon test; right hip more flexible), increased vertical leap ($p=0.0031$, Wilcoxon test), parental LBP history ($p=0.0849$, Fischer's Exact Test) and scoliosis ($p=0.0867$, Fischer's Exact Test). The study hypothesized that LBP could be triggered in predisposed FAVBP or aggravated in active LBP-suffering FAVBP by high-level, continuous volleyball and/or certain volleyball techniques. LBP in FAVBP may be related to predisposition to LBP (scoliosis, parental LBP history) but larger sample sizes are needed to determine this. Hip flexibility asymmetry and vertical leap correlated well with LBP in this small study. Interestingly, no correlation was found to LBP with greater back arch or trunk twist during serving or spiking or from landing on one leg after spiking. Major study limitations were low response rate (1.0% of all females ages 13-17 in the study area who played year-round volleyball) and lack of in-study scoliosis diagnoses. Although results obtained in the current study are an important first step, larger studies with many subjects are necessary to verify risk factors identified for LBP in FAVBP.

Key words: teenage female volleyball players; low back pain origin

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Lombalgie (LBP)is répandu parmi des joueurs de volleyball. En outre, LBP semble être un problème significatif parmi les adolescents féminins. Cette étude a été entreprise pour identifier des facteurs prévoyant LBP dans les joueurs adolescents féminins de volleyball jouant l'année ronde sur les équipes fortement concurrentielles. Dans une étude approuvée par le comité d'examen institutionnel d'université locale (IRB), vingt joueurs féminins de volleyball entre les âges de 13 et 17 ans de ont été recrutés par l'intermédiaire de la publicité IRB-approuvée dans un bulletin local de volleyball. Dizaines des sujets d'étude ont rapporté à lombalgie de la durée 1day à l'est les 6 derniers mois (groupe de LBP). Dix commandes d'âge comparable qui n'ont rapporté aucun LBP pendant au moins les deux dernières années ont été également inscrites dans l'étude (groupe de commande). Après un examen complet de la littérature, un certain

nombre d'indicateurs de LBP dans les femelles adolescentes ont été identifiés et combinés avec des mesures volleyball-spécifiques de compétence pour produire d'une série d'essais et de questions qui ont inclus : la démographie, la fréquence et la durée des pratiques en matière et des allumettes de volleyball, toute autre participation de sports à la dernière année, les antécédents medicaux (scoliose y compris et histoire de LBP) et les questions ont dérivé des indicateurs de la lombalgie trouvée dans des études précédentes incluant mais non limitée : jaillissements de croissance, histoire percoal de familaland de LBP, histoire d'accidents de voiture, se reposant à un bureau d'école, formation de poids, manque de sommeil, activité physique, début du cycle menstruel, heures par semaine regardant la TV ou sur l'ordinateur et les travaux après école. Le groupe de LBP a été en plus invité à remplir un questionnaire de douleur concernant leurs secteurs de douleur pendant les épisodes de LBP. Les deux groupes ont été alors examinés pour la force et la flexibilité de muscle de jambe, l'estomac et la force arrière (employant des essais précédemment validés en littérature pair-passée en revue), le saut et la torsion verticale se tenante de torse (torsion) et la flexion arrière (courbement) pendant clouer et servir. Des données ont été analysées d'une manière descriptive (des moyens, des gammes, des fréquences) et en utilisant les t-essais appareillés pour des comparaisons des groupes de LBP et de commande. Seulement quatre facteurs ont semblé être corrélés avec LBP : asymétrie active de flexion de hanche (sig=0.039, bonne jambe plus de flexion), saut vertical accru (sig=0.005), histoire parentale de LBP (0.074) et scoliose (sig=0.065). Les hypothèses de cette étude étaient que LBP pourrait être déclenché et les joueurs prédisposés de volleyball ou être aggravé dans les victimes actives de LBP par fortement concurrentiel, concurrence ronde de volleyball d'année et/ou technique inexacte de volleyball. Les résultats de ceci étudient le conseil que LBP est lié à la prédisposition à LBP (scoliose, histoire parentale de LBP) mais le petit nombre de sujets dans l'étude (histoire parentale) et le manque de dans-étudient le criblage pour la scoliose (scoliose) n'a pas permis à ces facteurs d'atteindre la signification statistique. Statistiquement (sig<0.05), deux facteurs se sont bien corrélés avec LBP : asymétrie de felxion de hanche et saut vertical. Le reason(s) exact pour ces corrélations dans peu clair mais lui est possible que le décollage asymétrique pendant clouer pourrait affecter la flexibilité de hanche asymétriquement et que les joueurs avec de meilleurs sauts verticaux pourraient jouer sur de meilleures équipes qui simuleraient plus étroitement haut-intenisty, concurrence de niveau d'université et présenter le plus grand moyen de l'activation de LBP latent. Aucune corrélation n'a été trouvée avec le technqiue inexact de volleyball comme mesurée par la voûte excessive du dos ou du village du tronc pendant la portion et de clouer. En outre, bien que 40% de participants d'étude ait fini leur saut de transitoire par le débarquement sur une jambe, aucune corrélation n'a été trouvée avec ces paramètre et LBP, l'un ou l'autre. Le nombre de victimes de LBP qui ont répondu à la publicité de bulletin de volleyball pour cette étude était très petit (10 sufferes de LBP hors de plus de 2000 filles 13-17 qui reçoivent ce bulletin). Ceci pourrait être le résultat d'un manque général de LBP dans des joueurs de volleyball dans la région de St Louis dans le groupe d'age/gender ou juste ces personnes n'ont pas voulu participer à cette étude. Dans l'un ou l'autre cas, le nombre limité de sujets de LBP a limité la puissance des données produites pour faire des prévisions sur la façon dont la participation de volleyball a affecté LBP. Une plus grande étude est clairement nécessaire pour voir si la corrélation de LBP, diagnsosed les joueurs féminins adolescents concurrentiels de volleyball avec l'histoire parentale de LBP, scoliose diagnostiquée, saut, asymétrie de flexion de hanche ou autre plus haut verticale, les prises encore-à-être-définies de paramters. En outre, en tant que rien la technique de volleyball les mesures ont montré la corrélation avec de nouveaux essais de LBP regardant les effets de la technique inexacte sur la nécessité arrière inférieure d'être conçu et mis en application dans de futures études à ce sujet.

INTRODUCTION

Low back pain (LBP) has been experienced by many volleyball players during and after competition and/or practice. LBP can either be acute or chronic. Normally, LBP is acute if it has a duration of about 1 month or less and chronic LBP is usually defined by symptoms of 2 months or more. The recent increase in the number of females playing volleyball essentially year-round (i.e., school season to club season to summer camps and back to school), coupled with the realization that low back pain is currently a significant loss time occurrence in female college volleyball players, led the authors to the question whether there are any underlying predictors for low back pain that might be identified in adolescent female volleyball players. If these predictors do exist and if they could be well understood, it is possible that better screening and prophylactic steps could prevent low back pain from becoming a chronic condition either during an athlete's playing career or later in life.

REVIEW OF THE LITERATURE

Adolescent low back pain (LBP) has been studied by a number of investigators [Balague, F., Nordin, M., Skovron, M.L., Dutoit, G., Yee, A., Waldburger, M. (1994); Balague, F., Skovron, M.L., Nordin, M., Dutoit, G., Pol, L.R., Waldburger, M. (1995); Burton, A.K., Clarke, R.D., McClune, T.D., Tillotson, K.M. (1996); Ebrall, P.S. (1994). Feldman, D.E., Shrier, I., Rossignol, M., Abenhaim, L. (2001); Feldman, D.E., Rossignol, M., Shrier, I., Abenhaim, L. (1999); Grimmer, K., Williams, M. (2000); Harreby, M., Nygaard, B., Jessen, T., Larsen, E., Storr-Paulsen, A., Lindahl, A., Fisker, I., Laegaard, E. (1999); Hutchinson, M.R. (1999); Kujala, U.M., Taimela, S., Viljanen, T. (1999); Kujala, U.M., Taimela, S., Oksanen, A., Salminen, J.J. (1997); Kujala, U.M., Taimela, S., Erkintalo, M., Salminen, J.J., Kaprio, J. (1996); Micheli, L.J. (1995); Newcomer, K., Sinaki, M. (1996); Steele, S., Grimmer, K., Williams, M., Gill, T. (2001); Salminen, J.J., Pentti, J., Terho, P. (1992); Taimela, S., Kujala, U.M., Salminen, J.J., Viljanen, T. (1997); Troussier, B., Marchou-Lopez, S., Pironneau, S., Alais, E., Grison, J., Prel, G., Pequegnot, C., DeGaudemaris, R., Phelip, X. (1999); Viry, P., Creveuil, C., Marceilli, C. (1999); Widhe, T. (2001)] and a number of reviews on the subject have been published [Balague, F., Nordin, M. (1992); Balague, F., Troussier, B., Salminen, J.J. (1999); Duggleby, T., Kumar, S. (1997); Phelip, X. (1999); Zitting, P., Vanharanta, H. (1998)]. Predictors for LBP in this subgroup, as indicated in the cited references, are shown in Table 1. Among

TABLE I – Data from published studies on low-back pain in adolescents

Ref.	Study Group	Percentage With LBP	Predictors of low back pain
Troussier, B, et al. (1999)	M/F, 10-14 yrs old, France		Rapid growth, scoliosis, family history of LBP, female gender
Steele, S., et al. (2001)	M/F, 11-18 yrs old, Australia		Subischial height (12-year-old females, 16-year-old males), weight (14-, 16-year-old females), female gender.
Viry, P., et al. (1999)	14-year-olds, France	82.9%	Female gender, school bookbag weight, distance carrying bookbag, uneven sitting weight distribution (L/R, A/P)
Kujala, U.M., et al. (1999)	10-17year-olds, Finland	6%	Sports participation
Burton, A.K., et al. (1996)	Longitudinal study of 11year-olds followed for four years	50%	Sports participation, male gender at 15+ years old, directly with age
Taimela, S., et al. (1997)	7-17-year-olds in Finland	1% to 18%	Directly with age, high levels of habitual physical activity
Balague, F., et al. (1995)	12-17-year-olds, Switzerland	74%	Female gender, positive and negative affect scores in Children's Depression Scale questions, low back pain in siblings
Feldman, D.E., et al. (1999)	Grades 7-9 (12-14- year-olds)	30%	Smoking
Balague, F., et al. (1994)	M/F ages 8-16 in Switzerland	21%	Age (>12, especially), Female gender, parental history of LBP, competitive sports (volleyball, cycling), tennis, television watching
Kujala, U M., et al. (1997), Kujal, U.M., et al. (1996)	98 M/F in Finland; follow-up study design w/controls	32%	Sports participation and low maximal lumbar flexion (boys); decreased ROM in low lumbar segments, low maximal lumbar extension and weight (girls)
Hutchinson, M.R. (1999)	11 F rhythmic gymnasts (ages 15-17), Chicago	86%	Rhythmic gymnastics
Newcomber, K., Sinaki, M. (1996)	96 M/F 10-19 years old in Minnesota	51%	Physical activity, stronger back flexors
Grimmer, K., Williams, M. (2000)	1269 M/F 12-18 years old in Australia	15-28%	Female gender, biological maturation (possible!), heavy school backpacks (some age groups), prolonged sitting
Harreby, M., et al. (1999)	1389 M/F 13-16	58.9%	Female gender, daily smoking, heavy

other findings in these studies, it was generally accepted that adolescent females report a greater incidence of LBP than adolescent males [Balague, F., et al (1995), Balague, F., et al (1994); Grimmer, K., Williams, M., (2000); Harreby, M., et al (1999); Kujala, U.M., et al (1997); Salminen, J.J., et al (1992); Steele, S., et al (2001); Troussier, B., et al (1999); Viry, et al (1999)] though

this has not been a universal finding [Burton, A.K., et al. (1996); Feldman, D.E., et al. (1999); Hutchinson, M.R. (1999); Kujala, U.M., et al. (1999); Kujala, U.M., et al. (1996); Newcomer, K., Sinaki, M., (1996); Taimela, S., et al. (1997)]. Although a lack of self-report of pain by adolescent males may play a part in females reporting more pain, it is clear from this data that LBP is a significant problem in adolescent females.

Not all the data is supportive of LBP in adolescents, however. A study by Solgard and co-workers [Solgard L., Nielsen, A.B., Moller-Madsen B., Jacobsen, B.W., Yde J., Jensen, J. (1995)] showed that relatively few low back pain incidents were reported, although the study's inclusion criteria clearly could have left out many low-back pain sufferers.

It has also been reported that participation in sports is a predictor for LBP in adolescents. [Balague, F., et al (1994); Burton, A.K., et al. (1996); Kujala, U.M., et al. (1999); Kujala, U.M., et al. (1997); Kujala, U.M., et al. (1996); Newcomer, K., Sinaki, M., (1996); Salminen, J.J., et al. (1992); Taimela, et al. (1997)] and a number of literature reports on LBP in adolescent and young adult athletes have also been published [Balague, F., et al. (1999); Balague, F., Nordin, M., (1994); Barakatt, E., Smidt, G.L., Dawson, J.D., Wei, S.H., Heiss, D.G. (1996); Blanda, J., Bethem, D., Moats, W., Lew, M. (1993); Briner, W.W., Benjamin, H.J. (1999); Duggleby, T., Kumar, S. (1997); Garry, J.P., McShane, J. (1998); Gerberich, S.G., Luhmann, S., Finke, C., Priest, J.D., Beard, B.J. (1987); Hickey, G.J., Fricker, P.A., McDonald, W.A. (1997); Lee, E.J., Etnyre, B.R., Poindexter, B.W., Sokol, D.L., Toon, T.J. (1989); Mason, D.E. (1999); Phelip, X. (1999); Ralston, S., Weir, M. (1998); Reeser, J.C. (2000); Zitting, P., Vanharanta, H. (1998)] including a small number of articles concerning volleyball players [Balague, F., et al. (1994); Gerberich, S.G., et al. (1987); Mason, D.E. (1999); Reeser, J.C. (2000)]. However, while there are a number of articles that mention low back pain in volleyball players [Bahr, R., Bahr, I.A. (1997); Bahr, R., Reeser, J.C. (2003); Bartolozzi, C., Caramella, D., Zampa, V., Dal Pozzo, G., Tinacci, E., Balducci, F. (1991); Blechri, M., Petridous E., Kedikoglous, S., Trichopoulos, D. (2001); Iwamoto, J., Takeda, T. (2003); Nakamura, T., Ikeda, T., Takagi, K., (2002); Nordstrom, D., Zwerling, C., Stromquist, A. (2000); Schafle, M.D. (1993); Schafle, M.D., Requa, R.K., Patton, W.L., Garrick, J.G., (1990); Schutz, L.K. (1999); Shah, M.K., Stewart, G.W. (2002)], there are no reports in the literature that address the causative factors for low back pain in adolescent female volleyball players. Indeed, Kujala and co-workers [Kujala, U.M., et al. (1996)] cautioned that there was an alarming paucity of sport-specific studies on LBP in adolescents and Boldori and co-workers [Boldori, L., Da Solda, M., Marelli, A. (1999)] suggested that orthopedic evaluation be an important pre-screen for children who want to play sports. Of particular interest to the current study, Bartolozzi and co-workers [Bartolozzi, et al. (1991)] noted that disk changes were significant in a large percentage of volleyball players that they examined by magnetic resonance imaging (MRI) and that these disk changes, present to a large extent in even young athletes (38.5% of 17-19-year-olds), might be a cause for concern, especially if training is done incorrectly.

A recent paper by Reeser [Reeser, J.C. (2000)] reported that 7-11% of injuries in female college volleyball players that result in missed practice and/or match time are due to low back pain. Also, a slightly older article addressed low back pain in athletes using oral contraceptives and, while showing no correlation with contraceptive use, did indicate a marked incidence of low back pain in female volleyball players (Brynhildsen, J., Lennartsson, H., Klemetz, M., Dahlquist, P., Hedin, B., Hammar, M. (1997)]. Neither of these articles appear to address risk factors for low back pain in female volleyball players adequately and the Reeser article [Reeser, J.C. (1997)] did not address the prevalence of non-debilitating chronic or acute LBP that goes undiagnosed in female volleyball players. Using the numbers from the Brynhildsen article [Brynhildsen, et al. (1997)], an additional number of LBP injuries over and above that reported by Reeser [Reeser, J.C. (2000)] can be expected that do not cause loss of practice, play or class time. It may, indeed, be these non-debilitating episodes that are the most dangerous into later stages of adulthood, as they may only be treated analgesically/symptomatically, if at all, not with the goal of curing any underlying musculoskeletal problem.

This pilot project was undertaken to determine the causes(s) for low back pain in adolescent female volleyball players. The hypothesis was that low back pain in volleyball players is probably not caused simply by volleyball participation, but rather that volleyball participation at a high frequency exacerbates the already existing potential for low back pain in an individual. The null hypothesis, then, would be that LBP in intensely competitive female adolescent volleyball players could not be correlated to a predisposition for LBP. It was also postulated that improper volleyball technique (form) in spiking and serving may contribute to LBP in athletes who have a predisposition to that condition. The null hypothesis for that statement would be that poor form does not produce such a relationship. In addition to these 2 study questions, predictors of LBP found by other investigators (Table 1) were also examined for relationship to LBP in this subgroup of adolescent females.

METHODS AND PROCEDURES

Methods: This research project was approved by the IRB of the college at which it was conducted. As the study involved minors, written parental consent and documented verbal participant consent was required for participation in this study. Twenty female volleyball players in grades 8-11 (10 subjects with history of low back pain (LBP) and 10 age-matched controls without any history of LBP) were recruited via IRB-approved advertising in a local volleyball newsletter. Inclusion criteria were: female, currently in or completed 8th and not yet started 12th grade, participated on their high school or grade school team and on a club team that practiced at least once a week, on average, between January and June; occurrence of LBP at least twice in the past 6 months lasting >1 day each occurrence (LBP group) or no occurrence of low back pain in the past 24 months (control group). Exclusion criteria were: previous back surgery or serious congenital back pathology, current acute low back pain, inability to lift weight, do sit-ups or perform strength, flexibility or volleyball skills testing, lack of parent or guardian-signed consent form, pregnancy (verbal ascent only).

Subjects were asked to complete a questionnaire that addressed demographics, frequency and intensity of volleyball practices and matches, frequency in change of volleyball shoes, other sports

participation in the past year, medical history (including scoliosis and LBP history) and questions derived from indicators for low back pain found in previous studies (Table 1), including but not limited to: growth spurts, familial and personal history of LBP, car accident history, sitting at a school desk, weight training, lack of sleep, physical activity, onset of menstrual cycle, hours per week watching TV or on computer and jobs after school. The LBP group was additionally asked to complete a pain questionnaire regarding their areas of pain during LBP episodes.

After completion of the questionnaire, the subjects were allowed to warm up with 5-7 minutes of brisk walking on a treadmill. They were then tested for height, balance (wearing socks but no shoes, 4-way weight scale (Chirotron®), abdominal muscle strength [Feldman, D.E., et al. (1999)], back muscle strength [Latimer, J., Maher, C.G., Refhauge, K., Colaco, I. (1999)] and the active flexibility of their hamstring [Hui, S.S., Yuen, P.Y. (2000)], hip [Lee, et al. (1989)] and quadriceps [Feldman, et al. (1999)] muscles of each leg, with all the above measurements being done in that order, if possible. All of the above measurements were made with techniques previously described and validated in the literature (as indicated by the reference listed with each test). Abdominal strength was measured by the subject pressing against a pre-calibrated hand-held dynamometer connected to a Dynatron 2000 strength testing apparatus held to their sternum as the subject tried to do a situp. The subject's torso was 10-20 degrees off the floor at the time of the measurement. All tests were carried out by student research assistants trained in those techniques.

The final testing was done in the college gymnasium. The subjects had their standing vertical leap measured against a wall (difference of standing reach and standing jump (maximum, one-handed reach) and then had florescent orange dots placed on: the outside of the shoulder (superior clavicular, acrominal joint) of their dominant arm, the navel area on their tucked-in-tightly shirt and on both hips at the iliac crest. This was done to identify landmarks to give a qualitative indication of flexion and torsion when analyzing the videotape. Subjects were then videotaped serving and spiking from the side trying to maintain a 90-degree angle of the camera with the subject's torso on the side of their dominant arm and the videotape analyzed for twist angle (torsion) of the shoulders relative to the hips and arch of the back (flexion) in serving and spiking. Flexion was defined as degrees of arch of the back as measured by constructing a line from the back of the neck to the dot on the hip and comparing the angle formed by that line and a vertical line drawn from the hip dot to the outside of the nearest knee. Torsional movement was excluded from the flexion measurement by not using the shoulder dot. Torsion was defined by the angle of a line from the shoulder dot to the hip dot compared to a vertical line from the knee to the hip. The alignment of the two hips relative to each other in the video was considered in order to subtract out any full body rotation in the air that might have been incorrectly added to the torsion measurement.

Data were analyzed for frequencies and, where appropriate, means (with standard deviations) and paired t-tests using SPSS 10.0. Additional correlative analysis was done using the statistical software package SAS 8.02. The effect of lower back pain on continuous (measured) variables was determined using the Wilcoxon Rank Sum Test. The relationship of LBP to two level (i.e., yes/no) categorical variables was determined using the 1- and 2-sided Fischer's Exact Test, which was used instead of Chi Square analysis due to the sparseness of the data in some cells of each of the 2 x 2 tables ($n < 5$). Means are reported with standard deviations and significance for correlation was set at the $p<0.05$ level.

Results: Two groups of girls participated in this study -- 10 with a history of LBP and 10 as age-matched controls. There were 3 high school juniors, 3 sophomores, 2 freshmen and 2 girls in the 8th grade in each group. Results for many of the variables examined in this study are summarized in Tables II and III (see pages 38, 39). In addition, 40 percent in the LBP group had diagnosed mild scoliosis and 50% had been in some kind of car accident. None of the controls had ever been diagnosed with scoliosis and 20% had been in a car accident. Twenty percent of the LBP group had been involved in some kind of accident (car or sports-related) that they (or their parents) felt initiated their low back pain with one of those two LBP group subjects having her accident coincide with the time of her largest growth spurt and the initiation of her menstrual cycles. Eighty percent of the LBP group had 1 or 2 parents who suffered from low back pain, but only 20% had 1 or more siblings who had LBP. This compared to 40% and 10%, respectively, for the control group. The mean duration of the low back pain episodes in the LBP group was 4.3+3 days with a high of 10 and a low of one day. Fifty percent of the LBP group had missed either school or sports as a result of low back pain and 40% had been to see a chiropractor on more than 1 occasion and sought chiropractic care when their back hurt. No correlation with LBP compared to controls was found with back strength, age at onset of menstrual cycle, height, weight, jobs after school, sports activity, abdominal muscle strength, individual leg quadriceps and hamstring flexibility and asymmetry, individual hip flexibility, balance (left/right and anterior/posterior), amount of weight training, amount of sleep, growth spurts, frequency of change in volleyball shoes, uncomfortable school desks, sibling history of LBP or TV/computer/ video game time. The following did show a relatively high level of correlation as being predictive of low back pain: hip flexibility asymmetry (right hip more flexible, paired t-test ($p=0.039$) and Wilcoxon Rank Sum Test ($p=0.036$) and greater vertical leap (paired t-test ($p=0.005$) and Wilcoxon ($p=0.0031$). Parental history of low back pain (paired t-test ($p=0.074$) and Fischer's Exact Test, one sided ($p=0.0849$) and two-sided ($p=0.1698$) and diagnosed scoliosis (paired t-test ($p=0.065$) and Fischer's Exact Test, one sided ($p=0.0433$) and two-sided ($p=0.0867$) correlated but did not reach significance. Scoliosis did reach significance using Chi Squared analysis ($p=0.0253$), but that test was shown not to be appropriate for this data set due to the asymmetry of the data as represented in the 2 x 2 correlative tables for this variable.

Eighty percent of the LBP group and zero percent in the control group indicated that their back hurt when they spiked the ball and served. Each subject had her spiking and serving form videotaped. Anecdotally, the subject with the most profound (largest number of episodes and of the greatest duration) incidence of LBP also rotated past her starting orientation in the landing phase of her spike approach, the only study subject in which that was observed. About 40% of study subjects completed the landing phase of spiking by first landing on their left foot. There was no

Table II – Statistical Measures of Low Back Pain in LBP and non-LBP Matched Groups**

Variable	Mean (± S.D.)		Minimum (all study subjects)	Maximum (all study subjects)	Paired t-test significance (p) vs presence of low back pain
	LBP	No LBP			
Height	1.72 (0.08) m	1.68 (0.09)	1.42	1.85	0.13
Weight	62.7 (9.9) kg	57.3 (2.5)	52.3	Not reported in this table	0.26
Weight balance L/R	1.8 (4.3) % right	0.4% (6.2) right	8% left	14% right	0.56
Weight balance A/P	4.3 (16.8) % posterior	2.7 (8.2) anterior	29% posterior	40% anterior	0.35
Abdominal Muscle Strength	16.9 (3.8) kg	16.4 (2.5)	9.55	21.4	0.71
Lower Back Strength	83.6(35.6) sec	83.6 (16.5)	56	176	0.99
Left Quad Flexibility	49.8 (5.0) deg	47.6 (6.7)	30	59	0.43
Right Quad Flexibility	53.8 (5.6) deg	49.9 (5.0)	37	67	0.12
Quad Flex Asymmetry	4.1 (6.0) deg right	2.5 (7.0) deg right	20 deg left	8 deg right	0.55
Left Hip Flexibility	88.3 (11.9) deg	86.7 (7.7)	82	107	0.38
Right Hip Flexibility	93.1 (10.6) deg	86.3 (7.7)	76	112	0.12
Hip Flex. Asymmetry	4.9 (5.8) deg right	0.4 (4.7) deg left	10 deg left	18 deg right	**0.039**
Left Hamstring Flexibility	49.0 (11.0) cm	46.7 (11.0)	25.4	63.5	0.651
Right Hamstring Flexibility	48.0 (10.2) cm	47.0 (9.1)	30.5	66.0	0.816
Hamstring Flex Asymmetry	2.5 (5.7) cm left	0.30 (4.3) cm right	10 cm left	7.6 cm right	0.159
Vertical Leap	45.5 (8.4) cm	35.6 (4.1)	25	62	**0.005**
Hours High School Practice per Week	9.65 (4.2) hr	9.95 (3.6)	2	13.5	0.87
Total HS matches	24 (5)	23 (4)	18	30	0.71
Hours Club Practice per Week	4.0 (1.1) hr	4.3 (1.0)	2	6	0.49
Total club matches	58 (29)	66 (24)	20	100	0.48

Table III - Percentage of Participants with Positive Responses to Test Variables**

Variable	LBP Group	Group without LBP	p versus LBP from paired t tests
Right-handed server/spiker	100%	100%	N/A
Ever in car accident	50%	20%	0.18
Subject remembers a discreet injury that was original cause of low back pain	20%	N/A	N/A
Low back pain has caused lost time from sports and/or school	50%	N/A	N/A
Parents with LBP	80%	40%	**0.074**
Subject previously diagnosed with mild scoliosis	40%	0%	**0.065**
Siblings with LBP	20%	10%	0.77
Landing on only left leg after spiking	50%	40%	0.46

** - Wilcoxon (for continuous variables) and Fischer's (for two level variables) correlations are not included for simplicity, as their p values were similar to what was found using paired t-tests. Chi Squared correlations are not included, as they were found to give inappropriately low p values for two level (yes/no) variables.

correlation with this left-foot landing to low back pain. It had been anticipated due to complaints in most of the LBP group that serving and spiking exacerbated their LBP that excessive back arch and trunk twist due to improper technique might exist. Analysis of serving and spiking form for excessive twisting or arching of the back or unusual landing after spiking did not provide any correlation with low back pain. Finally, although not a direct part of this study, no correlation (paired t-test, p=0.36) was found with onset of low back pain and onset of menstrual cycle and only a slight correlation (paired t-test, p=0.11) was found in A/P balance (posteriorally loaded) compared to diagnosed slight (mild) scoliosis, although the measurement of balance was not the same as that used by previous investigators [Byl N., Holland, S., Jurek A., Hu, S. (1997)].

Discussion: The statistics on debilitating, time-loss low back injuries in college volleyball players have shown that this is an important injury type requiring further and detailed consideration. College volleyball players play at a very high level, thus increasing the potential of overuse injuries and injuries related to underlying musculoskeletal weaknesses. An informal survey of college Web sites by the lead author indicated that probably greater than 80% of college freshman volleyball players at NCAA Division I schools played year-round volleyball at some point when they were in high school. In order to closely approximate the type of girls playing in college who might suffer low back pain, the current study only included girls who played at least a 6-month post-season (club volleyball) schedule in addition to their high school/grade school season. Although this may not be a truly accurate representation of the type of girls who play in college, for the purposes of this study it was the best that could be achieved.

Most of the predictors of low back pain in adolescents in other studies (Table I) were not found to be predictive of low back pain in the adolescent volleyball players in this study. It is quite possible that the subjects of the current study (control and LBP group) are more physically fit, on average, than those in previous adolescent low back pain studies and that this is the reason for the lack of correlation of these factors. Clearly, the subjects of this study are spending significant time conditioning, as the LBP group averaged 1.5 weight lifting sessions a week, almost identical to the control group. While the LBP group had slightly stronger stomach muscles, slightly stronger leg muscles (as evidenced by higher mean vertical leap) and more flexibility than the control group, none of these factors reached statistical significance.

The predictors of LBP that were found to correlate in this study are hip flexibility asymmetry (i.e., more right hip flexibility) and vertical leap. Volleyball is a game of fast-twitch muscle/explosive movements and the approach to the net to spike is one of the most explosive movements in the game. All the girls in this study are right-handed. Right handed hitters usually hit from the center or left side of the net (as they face it) and, as such, open their shoulders to the flight of the ball toward them (from the setter), partially by jumping with their left foot about 6-12 inches closer to the net than their right foot. It is not known in this population whether subtle asymmetric movements such as jumping from a staggered foot position to spike may cause slightly unequal development of leg and hip muscles or even slightly more torque on the body as it rights itself from this asymmetric takeoff immediately before landing on the ground. These could be possible explanations for the differences in right and left hip flexibility in the LBP group.

The higher average vertical leap in the LBP group could be

indicative of a number of things, not the least of which is that volleyball players with higher vertical leaps are sought after, if they are tall enough, to play on the best teams which are probably playing and practicing at the most college-like level. It appears that the competitive level was dominant in the LBP group as 7 of 10 of those girls had played on teams that had gone to the Junior National Championships the previous year as compared to 4 of 10 in the control group.

The first hypothesis of this study was that playing volleyball at a highly competitive level year-round could trigger LBP in girls predisposed to that condition. Parental history of LBP was present in 80% of the LBP group. This did not quite reach statistical significance, however, as 40% of the control group also reported parents with LBP. In addition to parental history, 40% of the LBP group reported that they had been diagnosed with mild scoliosis compared to 0% of the control group. Again, this narrowly failed to reach statistical significance as set in this study. As the incidence of idiopathic scoliosis is universally believed to be about 2% in the general population, however, it is a significant finding that 40% of the LBP group reported that they had been diagnosed as having mild scoliosis. Mild scoliosis is generally asymptomatic and, in some cases, not even related to low back pain in even the most elite athletes [Hutchinson (1999)]. As scoliosis screening is still not universally done on children and mild scoliosis may even go undiagnosed in cursory screenings, the lack of inclusion of an in-study screen for scoliosis limits the usefulness of this finding of near correlation of LBP with prior subject-reported diagnosis of scoliosis as it is not possible within the scope of this study to determine if scoliosis existed in any of the other study subjects (LBP or control group).

The second hypothesis of this study was that LBP could be exacerbated by improper volleyball technique. A majority (80%) of LBP subjects in this study said that their back hurt when they spiked and served. However, the simple measurements of back arching and trunk twisting during spiking and serving did not correlate well with low back pain in the subjects in this study. Indeed, torsion during spiking seemed to be greater in the control group. Even an unexpected finding of a large number (40%) of study participants landing exclusively on their left leg after spiking did not correlate well with low back pain. Thus, from the evidence presented in this study it is not possible to correlate low back pain and improper volleyball form, at least using the measurements of back arch, trunk twist and asymmetric jump landing.

This study had several limitations, the foremost one being the low number of subjects (10) in the LBP group. This represents approximately 0.5% of 13-17-year-old girls who play year-round volleyball in the area of the country in which the study was conducted. A low percentage of possible responders is not unusual in a study of this type, since the subjects were minors requiring parental consent and were recruited using only a single published advertisement. However, given the literature on numbers of volleyball players who may be expected to suffer from low back pain [Brynhildsen, J., et al. (1997) and Reeser, J.C. (2000)], the exact cause of this low number of responses is unknown, important and thus needs to be identified to determine, among other things, if the incidence of LBP in female adolescent volleyball players is lower than would have been expected. Other limitations to this study were the limited experience of the research assistants doing the measurements and any confounding injury or history factors that were not recorded properly by the parents or athletes.

CONCLUSIONS

The premise of this study was that highly competitive volleyball, especially if improper volleyball techniques were used, could trigger latent or exacerbate already existing low back pain. This study, though small, gave indications that latent problems could be triggered by highly competitive year-round volleyball competition and identified indicators (hip flexibility asymmetry, increased vertical leap) that seemed to correlate well with low back pain. In addition, although it is very possible that the LBP group had a greater risk, inherently, to develop low back pain (80% parental history of LBP, 40% mild scoliosis within the low back pain group), this could not be proven statistically in this small study due to the limited number of participants (parental history) and lack of screening for scoliosis in the both groups (scoliosis). A study with a larger number of participants needs to be conducted to determine if scoliosis and family history of LBP in adolescent female volleyball players are statistically significant risk factors. In addition, no correlation of LBP with improper volleyball technique (as measured by excessive twisting or back arching in spiking and serving) could be made even though a majority of the LBP subjects indicated that spiking and serving caused an onset of low back pain and/or intensified the pain during a LBP episode. This does not mean, necessarily, that improper technique does not lead to low back pain; it simply means that, using the measures in this study, no correlation was found.

IMPLICATIONS FOR COACHES

This study has given the first, though not conclusive, indication that low back pain in adolescent volleyball players may be linked to familial or congenital factors more than playing a highly competitive, explosive, jarring, twisting sport. Stronger indication exists that players with higher vertical leaps and statistically asymmetric hip flexibilities (right hip more flexible by >15 degrees) are more subject to low back pain. Further research needs to be done with much larger groups of subjects and controls to determine if volleyball is causing the circumstances that result in low back pain or if it is just acting on inherent, latent conditions that are already present in the athlete. Although no correlation was found between excessive back arch or twist in spiking and serving, it is nonetheless important that coaches continue to strive to teach good technique, especially in young, inexperienced players, as the current study used very skilled players, most of whom had relatively good technique and were physically well-trained.

Until a larger study is completed and the origins of low back pain in volleyball players is better understood, coaches should continue to be aware of and sensitive to player complaints of low back pain and recommend that those players complaining of low back pain seek professional healthcare attention. Additionally, it might help to gain knowledge of family history of low back pain and/or the presence of scoliosis in an athlete. This may help a coach be more aware of the potential for low back pain in that player.

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NEED BIOS FOR NOSCO ET AL

The Effect of Custom Orthotics on the Vertical Leap of Female Volleyball Players

William M. Austin, Foot Levelers, Inc., Roanoke, Virginia and
Dennis L. Nosco, Ph.D., Nosco Consulting, Florissant, Missouri (USA)

The scientific literature, in general, is devoid of reference to orthotics affecting vertical jump. A number of companies have attempted to produce shoe insoles or shoe-related devices designed to improve vertical jump in sports (i.e., basketball, volleyball, track and field jumping events) by methods such as improved force utilization by spring-back soles or by isolation and concomitant strengthening of calf muscles and lengthening of the Achilles tendon during training. These insoles and devices are, however, generic and address the general physics considerations of jumping without addressing or attempting to fine tune them for individual physiology. The current pilot project attempted to gather the first data on whether the use of custom orthotics in athletic shoes of a team in a jumping sport (volleyball) can positively affect the vertical jump in a controlled, masked study (null hypothesis = no change or negative effect on vertical jump with these insoles).

Eleven 11th and 12th grade female high school-age volleyball players from a local elite club team in Southern Virginia were recruited to participate in this pilot study. The participants were fitted for custom orthotics supplied by Foot Levelers, Inc. The orthotics were only worn during testing. Standing (first test session) and 3-step approach vertical jump (second test session) were measured with and without orthotics in separate practices 1 month apart. Vertical jump measurements were made using a Vertec® vertical jump measurement device to minimize measurement bias. This device measures to the nearest 0.5 inches (1.3 cm). Vertical jump (vertical jump reach minus standing reach) was determined as the best of 3 attempts for each of the 4 measurement conditions. Statistical analysis was done using descriptive statistics and linear regression. The mean vertical jump difference was 14.0 cm between the first (standing vertical jump) and second (approach vertical jump) test sessions. There was a mean increase 0.36 cm in vertical jump using orthotics in the first testing session and 0.59 cm in the second testing session. In the first test session, 5 participants showed improvement in their vertical jump, 2 stayed the same and 4 showed a decrease in vertical jump after putting in orthotics. At the second testing session, 5 participants showed increase in vertical jump, 4 stayed the same and 2 showed a decrease in vertical jump after wearing orthotics. Linear regression indicated a high correlation ($r2 = 0.896$ for the first testing session and 0.950 for the second session) for vertical jump values before and after orthotics within 1 testing session. This pilot study was performed with the intention of determining if a larger, more well-controlled study should be undertaken. The results show trends that would indicate that there is probably some benefit to orthotics in improving vertical jump, even in very limited exposure to the orthotics (i.e., only during the test). The changes, however, were very small (2.54 cm or less per participant) and so the possibility can not be excluded that the orthotics exerted little effect, positively or negatively, on the vertical jump of the participant. A lack of change, in itself, would be an interesting finding as published studies suggest that biomechanical changes are affected by wearing custom orthotics. Linear regression analysis shows good correlation between vertical jump values pre- and post-insertion of orthotics in each testing session and there is a mean positive effect in both standing (0.36 cm) and 3-step approach (0.59 cm) when wearing orthotics during the test. There was a lack of correlation of increases in vertical jump between the first and second testing sessions. This study indicated that custom orthotics do no adversely affect a player's vertical jump and may have a positive effect on their vertical jump.

The scientific literature, in general, is devoid of reference to orthotics affecting vertical jump. A number of companies have attempted to produce shoe insoles or shoe-related devices designed to improve vertical jump in sports (i.e., basketball, volleyball, track and field jumping events) by methods such as improved force utilization by spring-back soles or by isolation and concomitant strengthening of calf muscles and lengthening of the Achilles tendon during training. These insoles and devices are, however, generic and address the general physics considerations of jumping without addressing or attempting to fine tune them for individual physiology. The current pilot project attempted to gather the first data on whether the use of custom orthotics in athletic shoes of a team in a jumping sport (volleyball) can positively affect the vertical jump in a controlled, masked study (null hypothesis = no change or negative effect on vertical jump with these insoles).

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La littérature scientifique est généralement exempte de n'importe quel référence à l'orthotics affectant le saut vertical. Un certain nombre de compagnies ont essayé de produire des semelles intérieures de chaussure ou des dispositifs chaussure-connexes conçus pour améliorer le saut vertical dans des sports sautants (des événements sautants c.-à-d., de basket-ball, de volleyball, de voie et de champ) par des méthodes telles que l'utilisation améliorée de force par des semelles de ressort-en arrière ou l'isolement et le renforcement concomitant des muscles de veau et en rallongeant du tendon d'Achilles pendant la formation. Ces semelles intérieures et dispositifs sont génériques et adressent la physique générale de sauter sans adresser ou en essayant à fin accordez-les pour la physiologie individuelle. Le projet pilote en cours a essayé de recueillir les premières données dessus si l'utilisation de l'orthotics fait sur commande dans des chaussures sportives d'une équipe dans un sport sautant (volleyball) peut franchement affecter le saut vertical dans une étude masquée commandée (changement nul de hypotesis=no ou effet négatif sur le saut vertical avec ces semelles intérieures). Onze hauts joueurs écoliers féminins de volleyball d'une équipe locale de club d'élite en Virginie méridionale ont été recrutés pour participer à cette étude préliminaire. Des participants ont été adaptés pour l'orthotics fait sur commande fourni par Foot Levelers, Inc.. L'orthotics ont été seulement portés pendant l'essai. Se tenir (première session d'essai) et le saut vertical d'approche en trois étapes (deuxième session d'essai) ont été mesurés avec ou sans l'ortotics dans des pratiques séparées un mois de distantes.

Des mesures verticales de saut ont été faites à l'aide d'un dispositif vertical de mesure de saut de Vertec pour réduire au minimum la polarisation de mesure. Ce dispositif mesure à 0.5 pouce les plus proches (1.3 centimètre). Le saut vertical (extension verticale de saut sans l'extension se tenante) a été déterminé en tant que meilleur de trois tentatives pour chacun des quatre conditions de mesure. L'analyse statistique a été accomplie en utilisant des statistiques descriptives et la régression linéaire. La différence verticale moyenne de saut était de 14.0 centimètres entre le premier (saut vertical se tenant) et en second lieu (des sessions verticales d'essai de saut d'approche). Il y avait une augmentation moyenne 0.36 centimètre de saut vertical en utilisant l'orthotics en la première session d'essai et 0.59 centimètre en la deuxième session d'essai. En la première session d'essai, 5 participants ont montré l'amélioration de leur saut vertical, 2 sont restés la même chose et 4 ont montré une diminution de saut vertical après la mise dans l'orthotics. Deuxième à la session d'essai 5 les sujets ont montré l'augmentation du saut vertical, quatre sont restés la même chose et deux ont montré une diminution de saut vertical après port de l'orthotics. La régression linéaire a indiqué une corrélation élevée (r=0.896 pour la première session d'essai et 0.950 pour la deuxième session) pour de saut de valeurs l'orthotics vertical avant et après à moins d'une session d'essai.

Cette étude préliminaire a été réalisée avec l'intention de déterminer si une plus grande, bien-commandée étude est entreprise. Les résultats montrent que les tendances qui indiqueraient qu'il y a probablement un certain avantage à l'orthotics en améliorant le saut vertical même dans très linted l'exposition à l'orthotics (c.-à-d., seulement pendant l'essai). Les changements cependant, étaient très petits (2.54 centimètres ou moins par sujet). On ne peut pas exclure la possibilité que l'orthotics a exercé peu d'effet, franchement ou négativement, sur le saut vertical du participant. Un manque de changement, en soi, intéresserait la conclusion comme les studeis édités suggèrent que des changements biomécaniques soient affectés en portant l'orthotics fait sur commande. L'analyse de régression linéaire a montré que la bonne corrélation entre les valeurs de sauts pré-et l'poteau-insertion verticales de l'orthotics en chaque chaque session d'essai et il y a un effet postive moyen en tous les deux qui se tiennent (0.36 centimètre) et approche de 3 étapes (0.59 centimètre) quand orthotics de port pendant l'essai. Il y avait un manque de corrélation des augmentations du saut vertical entre les premières et deuxièmes sessions d'essai.

Cette étude a indiqué que l'orthotics fait sur commande ne compromettent pas un saut vertical de player's et peuvent avoir un effet positif sur leur saut vertical.

INTRODUCTION

The scientific literature, in general, is devoid of reference to orthotics affecting vertical jump. The current pilot project attempts to gather the first data on whether the use of custom orthotics in athletic shoes of a jump sport team can positively affect the vertical jump in a controlled, masked study (null hypothesis = no change or negative effect on vertical jump with these insoles).

REVIEW OF THE LITERATURE

A number of companies have attempted to produce shoe insoles or shoe-related devices designed to improve vertical jump in jumping sports (i.e., basketball, volleyball, track and field jumping events) by methods such as improved force utilization by spring-back soles or by isolation and concomitant strengthening of calf muscles and lengthening of the Achilles tendon during training (Flarity, Shilstone, Church, Fisher, 1997). However, these insoles and devices are generic and address the general physics considerations of jumping without addressing or attempting to fine-tune them for individual physiology.

The biomechanics and physiology of jumping have been well-documented [Anderson & Pandy (1999); Bobbert & Van Soest (1994); Fukashiro & Komi (1987); Hedrick & Anderson (1996); Hudson (1986); Jaric, Ristanovic, Corcos (1989); Le Pellec & Maton (2002); Marcora & Miller (2000); Pandy, Zajac, Sim, Levine, (1990); Robertson & Fleming (1987)]. Pandy and colleagues [Pandy, et al. (1990)] were among the first to develop a computer model that seemed to mimic human jumping. However, their model was complex and included 24 different "states" in the jumping process. Specifically, regarding the lower extremities, they comment that "the action of lower extremity musculature is to try to force the heel into the ground, while the spring exerts an equal and opposite torque on the foot." Maximizing this push-off force, everything else (e.g., fast-twitch muscle firing [Caruso, Hernandez, Schweickert, Saito, Hamill, DeGarmo (2003)]) being equal, is what will maximize the vertical jump. Loss of upward thrust to force vectors in other directions or to absorbance of energy by footwear will lessen the force available for vertical jump. This concept has been "sold" to a number of teams/organizations in "jumping" sports, including the United States Olympic volleyball teams, which use insoles that are designed to increase vertical jump by maximizing spring through minimizing the dampening loss of energy to other processes[1].

There are a number of papers describing muscular contributions to vertical jump [Beneliyahu & Duke (1992); Robertson & Fleming (1987)]. For example, Robertson and Fleming describe the contribution of individual muscle groups to vertical jump, indicating that hip flexors contribute 40% of the force to vertical jump. While biomechanics of normal models should naturally lead to discussions of the biomechanics of the less-than-ideal world of the average human participant, no such discussion has appeared in the literature.

There have been no reports of attempts to incorporate the use of custom orthotic insoles to improve the force utilization during vertical jump either by (a) combining the technology of custom orthotic insoles with the technology of generic jump-enhancing insoles or (b) simply using custom orthotics designed to optimize musculoskeletal function in existing athletic shoes to attempt to improve vertical jump.

PROCEDURES

Eleven 11th and 12th grade female high school-age volleyball players from a local elite club team in Southern Virginia were recruited to participate in this pilot study. Parental informed consent was obtained before any protocol procedures were started. The participants, who were masked to the endpoint of the study, were fitted for custom orthotics supplied by Foot Levelers, Inc. Orthotics were worn only during testing. Vertical jump was defined as the difference between standing reach and vertical jump reach. Standing (first test session) and 3-step approach vertical reach (second test session) were measured with and without orthotics in separate practices 1 month apart to minimize complicating fatigue factors [Psek & Cafarelli (1993); Rodacki, Fowler, & Bennett (2002)]. Testing was done at almost the same time of day and at the same point in practice at both test sessions. The order (with orthotic and without orthotic) was randomized for each girl and each measurement date. Vertical jump measurements were made using a Vertec® vertical jump measurement device to minimize measurement bias. This device measures to the nearest 0.5 inches (1.3 cm). Vertical jump (standing or approach vertical jump minus standing reach) was determined as the best of 3 attempts for each of the 4 measurement conditions (i.e., standing vertical with and without orthotics and approach vertical with and without orthotics). Statistical analysis was done using descriptive statistics and linear regression.

RESULTS

The results are shown in Tables 1 and 2. The mean vertical jump difference was 14.0 cm between the first (standing vertical jump) and second (approach vertical jump) test sessions. There was a mean increase in vertical jump of 0.36 cm using orthotics in the first testing session and 0.59 cm in the second testing session. In the first test session, 5 participants showed improvement in their vertical jump, 2 stayed the same and 4 showed a decrease in vertical jump after putting on orthotics. At the second testing session, 5 participants showed increase in vertical jump, 4 stayed the same and 2 showed a decrease in vertical jump after wearing orthotics. Linear regression indicated a high correlation ($r2 = 0.896$ for the first testing session and 0.950 for the second session) for vertical jump values before and after orthotics within 1 testing session.

DISCUSSION

Vertical jump is an inextricable part of sports such as basketball and volleyball [Gross & Nelson (1988); Hunter & Marshall (2002); Lee, Etnyre, Poindexter, Sokol, & Toon (1989); Richards, Ajemian, Wiley, Brunet, & Zernicke (2002)]. Coaches, athletic trainers and others continue to look for better, faster training methods to increase vertical jump in athletes and athletes continue to strive for the same goal. Nevertheless, the use of custom orthotics [Afheldt & Ball (2002); Ball & Afheldt (2002)] to help achieve this goal has been vastly under-considered. Indeed, Kuhn recently published two papers [Kuhn, Shibley, & Austin (1999); Kuhn, Yochum, Cherry, & Rodgers (2002)] which represent some of the first published work addressing lower extremity modifica-

Table 1 – Raw data from vertical jump study

Partici-pant	Standing reach (meters)	Standing vertical jump without orthotics, first testing session (meters)	Standing vertical jump with orthotics first testing session (meters)	Approach vertical jump without orthotics, second testing session (meters)	Approach vertical jump with orthotics, second testing session (meters)
1	2.13	2.55	2.55	2.70	2.70
2	2.31	2.67	2.69	2.83	2.86
3	2.16	2.44	2.44	2.62	2.62
4	2.18	2.59	101	2.73	2.73
5	1.94	2.34	257	2.45	2.48
6	2.26	2.56	2.58	2.65	2.68
7	2.24	2.56	2.59	2.72	2.71
8	2.26	2.59	2.58	2.68	2.71
9	2.27	262	2.59	2.77	2.78
10	2.08	2.52	2.54	2.68	2.68
11	2.26	2.72	2.74	2.82	2.83

Table 2 – Vertical Leap Differences With and Without Orthotics

Participant	Difference (+ = increase, - = decrease with orthotics) of standing vertical jump with and without orthotics at first test session (cm)	Difference (+ = increase, - = decrease with orthotics) of approach vertical jump with and without orthotics at second test session (cm)
1	0	0
2	2.5	2.5
3	0	0
4	-2.5	0
5	-1.2	1.2
6	1.2	-1.2
7	2.5	-1.2
8	-1.2	2.5
9	-2.5	1.2
10	2.5	0
11	2.5	1.2

tions that can be made using custom orthotics. Kuhn successfully demonstrated positive static alignment changes to the foot/ankle complex and the knee in participants after they wore orthotics. Both papers by Kuhn discuss aspects of lower extremity alignment that have also been considered by authors looking to model vertical jump mechanics.

The current pilot project explored a possible practical utilization of lower extremity modification with orthotics to increase vertical jump in young, well-trained athletes. The literature contains many references to biomechanical model studies and practical studies detailing the biomechanics of jumping [Anderson & Pandy (1999); Bobbert & Van Soest (1994); Fukashiro & Komi (1987); Hedrick & Anderson (1996); Hudson (1986); Jaric, et al. (1989); Le Pellec & Maton (2002); Marcora & Miller (2000); Pandy, et al. (1990); Robertson & Fleming (1987)]. It is clear from reading this literature that (a) jumping is a complex neuromusculoskeletal activity and (b) that there is not general agreement about how to model this activity or maximize training. In theory, custom-made orthotic devices would promote a more biomechanically efficient and, therefore, stronger movement pattern of the athlete's lower extremities in general and of the feet in particular [Subotnick (1999)]. While the theoretical considerations of the effects of orthotics on increasing vertical jump have not yet been fully explored, it was decided to begin the practical phase of

that exploration, i.e., a pilot study looking at vertical jump performance in participants tested with and without orthotics.

This experimental approach employed has many limitations. First, as a pilot study, the data set is underpowered, limiting the conclusions that can be drawn from the data. Practical power calculations indicate that a larger number (>50) of participants is necessary to test the null hypothesis appropriately. Second, under the conditions employed in any study of this type, it is very difficult to carry out true masking of study participants. Third, as jumping is a complex activity, it is difficult to define all systematic errors or control random errors such as, but not limited to, injuries (acute or latent) or menstrual cycle changes that might affect sensitivity of the participant to the effects of custom orthotics. Fourth, the small (< 2.54 cm) magnitude of the changes using a measuring device graduated to the nearest 1.27 cm (0.5 inches) could allow for uncontrolled variables to exert a large effect on the results. Fifth, it is generally accepted that a break-in period is necessary to maximize the effectiveness of orthotics and so the study design (i.e., measuring participants almost immediately after they put the orthotics in) did not allow for the maximum benefit to be gained. Finally, no comparison between sessions is possible to help strengthen data on magnitude and direction of change of vertical jump in each study participant as the study design consisted of one session using standing vertical jump and one using approach vertical jump. It is highly possible that the effect of orthotics on standing and approach vertical jump could be different based on differences in the biomechanics of the two movements.

Nevertheless, the pilot study was performed with the intention of determining if a larger, more well-controlled study should be undertaken. The results show trends that would indicate that there is probably some benefit to orthotics in improving vertical jump, even in very limited exposure to those orthotics (i.e., only during the test). However, the changes were very small; therefore, the possibility can not be excluded that the orthotics exerted little effect, positively or negatively, on the vertical jump of the participant. A lack of change, in itself, would be an interesting finding, as Kuhn's studies suggest that biomechanical changes are affected by wearing custom orthotics, albeit for longer periods of time (>30 days).

The increase in measured vertical jump from the first to the second session is logical both in direction and magnitude when comparing changes in standing and approach vertical jumps within the same individual. However, standing vertical jump and approach vertical jump apply slightly different sets and order of involvement of musculature [Anderson & Pandy (1999); Bobbert & Van Soest (1994); Hedrick & Anderson (1996); Jaric, et al. (1989); Marcora & Miller (2000); Pandy, et al. (1990)]. Thus, comparison of changes due to orthotics in these 2 separate jumps may not be possible. This may explain the poor correlation of changes in individuals (with and without orthotics) found in the standing vertical jump and the approach vertical jump. Nevertheless, linear regression analysis shows good correlation between vertical jump values pre- and post-insertion of orthotics in each testing session and there is a mean positive effect in both standing (0.36 cm) and 3-step approach (0.59 cm) when wearing orthotics during the test.

CONCLUSION

Although the exact mechanism or magnitude of a positive effect on vertical jump from orthotics is not yet understood, and given that the limited results and magnitude of changes do not lend themselves to extensive statistical analysis, the results of this study suggest that further studies are warranted to determine the magnitude, if any, of positive changes on vertical jump from orthotics. It is suggested that large, well-controlled studies be carried out to test the null hypothesis with participant numbers that will produce the power necessary to address the hypothesis of this study: wearing custom orthotics can have a positive effect on vertical jump. This study indicates that custom orthotics do not adversely affect a player's vertical jump. Larger studies will be more conclusive.

IMPLICATIONS FOR COACHES

The concept of specialized training to improve vertical jump in volleyball has been around for decades. Nevertheless, coaches should take care to advise athletes to check with their doctors before starting any vertical jump enhancement program as underlying musculoskeletal conditions may impact that training. With regard to orthotics, it is not clear from the literature or the results of this study that wearing custom orthotics in volleyball shoes produces any positive benefits. As studies are done that address this point more adequately, it may be possible to determine if custom orthotics for volleyball shoes may, indeed, increase performance and lessen the chance for repetitive use or catastrophic injury due to better musculoskeletal alignment in the athlete.

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NEED BIOS

Methods for Testing Individual Abilities of 13–16-Year-Old Female Volleyball Players and Assessment of Their Proficiency in the Game

Raini Stamm, University of Tartu (Estonia)

This study analyzed the body structure of 46 female volleyball players aged 13–16 years (49 body measurements, including 11 skinfolds) and the results of 9 physical fitness tests, 9 volleyball technical tests and 21 psychophysiological tests. In parallel, 32 players' performances at competitions were registered by an original volleyball recording program titled the Game, and body structure and test results were correlated with proficiency in the game. The structure of the body implies that very different body measurements can be applied in volleyball research, and correlation analysis should help to establish which body measurements are essential for the task studied.

The tests showed a correlation with body structure, between themselves, and were essential for assessing proficiency in the game. Thus, by means of a regression model consisting of 14 anthropometric variables, it was possible to predict the girls' proficiency in performing the serve, reception, block, feint and attack within 32–83%; 4 physical ability tests were essential in reception (R2 = 0.44), feint (R2 = 0.18) and attack (R2 = 0.22). Psychophysiological models were essential for reception, feint and attack (R2 = 0.39–0.80). Volleyball technical models were essential in the efficiency of reception within 32% and feint within 44%.

The correlation of individual anthropometric measurements with tests results, as well as with proficiency in the game, shows that one constitutional whole exists, which needs integrated assessment.

Key words: adolescent girls, volleyball, body structure, anthropometric measurements

L'étude a analysé la structure de corps de 46 joueurs féminins de volleyball âgés 13-16 ans (49 mesures de corps, y compris 11 skinfolds) aussi bien que les résultats de 9 essais physcial de forme physique, de 9 essais techniques de volleyball et de 21 essais psychophysiologiques. Des exécution de joueurs de trente deux aux compettions ont été également enregistrés par un jeu original de programme d'enregistrement de volleyball, et des résultats d'essai de structure de corps ont été corrélés avec la compétence dans le jeu. La structure du corps implique que des mesures très différentes de corps peuvent être appliquées dans la recherche de volleyball. L'analyse de corrélation devrait aider à établir quelles mesures de corps sont essentielles pour le charger étudié.

Les essais ont montré une corrélation avec la structure de corps entre eux-mêmes et étaient essentiels pour évaluer la compétence dans le jeu. Au moyen d'une régression modèle se composant de 14 variables anthropométriques alors, il était possible de prévoir les filles' ; compétence en effectuant le service, le réception, le bloc, la repasse et l'attaque dans 32-83& ; quatre essais physiques de capacités étaient essentiels dans la réception (R2=0.44), la repasse (R2=0.18) et l'attaque (R2=0.22). Les modèles psychophysiologiques étaient essentiels dans l'efficacité de la réception à moins de 32% et de la repasse à moins de 44%. Le système régulier de la structure de corps, corrélation de différentes mesures anthropométriques avec des résultats d'essai, comme avec la compétence dans le jeu prouve que le corps existe au total, qui a besoin d'évaluation intégrée.

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REVIEW OF LITERATURE

The game of volleyball requires the application of a variety of different abilities. In order to gain an integrated assessment of the level of young players, several tests should be applied and performance of all the significant elements of the game should be evaluated individually. One of the most essential aspects is the body build of young female players. Although it is generally known that volleyball players are usually taller and heavier than their peers (Thissen-Milder and Mayhew, 1991; Malina, 1994), there is no common understanding about which body dimensions should be measured to characterize the body build as a whole.

Among the tests, the most essential ones involve physical abilities: height of jump, arms and legs muscle strength, tests of flexibility, tests of endurance, indicators of explosive strength of

arms and upper body (Häkkinen et al., 1989; Bale et al., 1992; Engel et al., 2001). In literature, these tests have often been applied in combination.

Technical skills of volleyball are classical and well known to each coach. It has been emphasized that particularly for young volleyball players, special technical tests have to be devised, but there is no common stance regarding what these tests should include (Thissen-Milder & Mayhew, 1991). Relying on literature data and our own experience in coaching (Stamm, et al., 2002), we can recommend that the tests could include the main technical elements used in the game, like overhead pass, forearm pass, serve, reception of serve, spike and feint, performed outside the game situation. Usually such tests assess the mastery of the given technical element by the player by number of repetitions, precision of directing the ball, the direction of the ball's movement and the ball's trajectory.

Contemporary volleyball requires from players quick reaction to the rapidly changing situations in the game. For this purpose, the development of certain psychophysiological qualities in the players and assessment of their quality are necessary. Respective studies on volleyball have been conducted in India (Sharma et al., 1986), Turkey (Hascelik et al., 1989), Greece (Kiomourtzoglou et al., 2000), Germany (Hackfort and Schmidt, 2001) and Estonia (Thomson, 1992, 1997). Most often, psychophysiological tests study reaction times to visual or auditory stimuli. Unfortunately, after a thorough search of the literature, these tests have not yet reached the practice of young female players' coaching.

The result of a volleyball match always depends on the performance of each individual player. Therefore, several methods have been devised for assessing players' individual proficiency during the match. The newer methodologies apply various computer programs for recording the matches (Westphal et al., 2001, Peglar, 2000), special volleyball recording systems (FIVB Volleyball Information System, Version 2, 51, 1997; Nõlvak, 1995; Stamm, et al., 2000). Considering the above-mentioned, the author established the aim to perform an integrated analysis of body structure, different tests and players' individual performance in the game for assessment of young female volleyball players.

MATERIAL AND METHODS

Participants

The sample consisted of 46 female volleyball players aged 13–16 years. They came from 6 teams, the overall number of similar teams in Estonia being 10. All players practiced volleyball regularly and participated in young female volleyball players' championships in the age group of up to 16-year-olds.

Research procedures

Following is a detailed description of all the research methods to provide an opportunity for those who are interested in the matter to compare our results with their own data. The criterion for choosing physical abilities and volleyball technical skills tests was that they should be relatively simple and would not need expensive equipment. All the tests were conducted in the training hall. To conduct psychophysiological tests and register the players' proficiency at competitions, special computer programs were used.

Anthropometric Research

The girls were healthy, and their sexual development corresponded to Tanner's (1962) stages III–IV. Forty-six girls were measured (49 basic measurements, including 11 skinfolds). The girls were measured according to the classical method of Martin (Knussmann, 1988); lower extremity length was measured by the method of K.S. Jatsuta (1923). The measurements included height and weight, and, in addition, 11 length measurements, 6 breadth and depth measurements, 4 bone thicknesses (femur, ankle, humerus and wrist), 15 circumferences and 11 skinfolds.

Physical Fitness Tests

All the participants passed the following 9 validated tests of physical fitness. Jumping ability was measured by 2 vertical jump performance tests: standing vertical jump and reach (PA1) and running vertical jump and reach (PA2) (Young et al., 1997). The height of standing (PA3) and running (PA4) vertical jump was calculated by subtracting from PA1 and PA2 the length of the outstretched arm. Maximum aerobic endurance was measured by 20m shuttle run test PA5 (Leger et al., 1988). Trunk strength (PA6) was measured using a sit-up test by Brewer and Davis (1993). The flexibility test (PA7) measured the extent of bending forward from sitting position (Larson, 1974). Deftness and speed of movement was measured by a zigzag run test PA8 (Kuramsin, 1985). Upper body and arms strength were measured by a medicine ball throwing test PA9 (Viitasalo, 1988).

Volleyball Technical Tests

Mastery of volleyball skills was evaluated by 9 tests compiled by the author of the paper. All tests were based on the classical elements of volleyball. They included 2 overhead pass tests (T1, T2), a forearm pass test (T3), 2 serve tests (T7, T8), a reception test (T9), 2 spike tests (T4, T5) and a feint test (T6).

Psychophysiological Tests

The girls' psychophysiological abilities were measured by the following 4 kinds of computerized tests (n = 21).

1. Perception of the speed of a moving object. In 3 series, the participant had to assess the speed of an object moving on the computer screen (8 attempts in each series). Based on this, the program calculated the average value of speed assessment correctness in points, separately for each series (A1, A3, A5) and the average time needed for assessment in seconds (A2, A4, A6). The test result was the more points the participants achieved the better and the less time was needed for giving the assessment.

2. Auditory reaction was studied by 3 different stimuli (8 attempts for each stimulus). The reaction time was recorded separately for the right and the left hand. The program calculated the average reaction time for the right (B1, B3, B5) and the left hand (B2, B4, B6).

3. Visual reaction was also studied by 3 different stimuli (8 attempts for each stimulus), separately with the right and the left hand. The program calculated the average visual reaction time for the right (C1, C3, C5) and the left hand (C2, C4, C6).

4. If auditory and visual tests were viewed as single reactions, the speed perception test was evaluated as a complex reaction. Here the participants had to assess moving objects moving at dif-

ferent speeds, adopt a decision and react only after that. Therefore, in order to compare individually the speed of processing different information, we calculated the difference in seconds between complex reaction time (A2, A4, A6) and perception time of visual stimuli as a simple reaction (C1–C6). The respective test was called the test of anticipatory reflection of reality (D1–D3), and its results were calculated in the following way:

D1 = A2 – ; D2 = A4 – ; D3 = A6 – .

The methodology of psychophysiological tests for volleyball players was mostly based on the well-substantiated methodologies of Kioumourtzoglou et al. (2000) and Hascelik et al. (1989). The apparatus used by us for psychophysiological studies has been patented in Moscow on 8 June 1992 (No. 1766372) (Thomson, 1992) and accepted for use by the IX World Congress of Sport Physiology in Israel in 1997 (Thomson, 1997).

PLAYERS' PROFICIENCY

To assess players' proficiency at competitions, an original volleyball recording program Game, devised by the author, was used (Nõlvak, 1995). This program has been applied by the Estonian Volleyball Federation and has been introduced in the *International Journal of Volleyball Research* (Stamm, et al., 2000). The results were recorded at Estonian Championship and Cup matches for up to 16-year-olds, in which the 32 players under investigation participated.

All girls played on the teams where they practiced. The games were recorded within 3 months in different cities of Estonia where the matches took place. All players were assessed on the basis of at least 4 matches.

Technically, the assessment of players' proficiency proceeded as follows: during the game a recording assistant (a volleyball expert) fixed the performance of each technical element by each player of 1 team by pressing, according to the program, 3 keys on the computer keyboard. The following was recorded: 1) the element of the game that was performed; 2) grade for its performance on a 5-point scale (1–excellent … 5–failed); 3) the number of the player who performed the element. Each player's proficiency in all the elements they performed was calculated by the following formula:

Index of proficiency =

Proficiency can range from 0 to 1, where 1 means that in all the cases the element was performed excellently, and 0 — a failure in all the cases.

Statistical analysis was conducted using a multivariate analysis at the Institute of Mathematical Statistics, Faculty of Mathematics, University of Tartu, Estonia.

RESULTS AND DISCUSSION

Anthropometric characteristics were subjected to correlation analysis, and the possibilities of predicting each characteristic from height, weight and age were studied. Anthropometric structure of the body as a whole consists of individual characteristics that are strongly correlated, where the primary characteristics are height and weight. As in this sample, all the basic characteristics are predictable statistically significantly from height, weight and age, then each basic characteristic is essential for the body as a whole as it represents not only a concrete measurement of the body but partially also the body as a whole. Consequently, in volleyball research, a great number of body measurements can be used, and correlation analysis should help to select the most essential features for the task studied. Thus, the regularity of body structure facilitates the performance of detailed anthropometric analysis (Martirosov, 2001; Avloniti, 2001).

The results of physical abilities are recorded in tables. Volleyball technical skills and psychophysiological tests and correlate the results with age and body build. The results of all the tests showed correlation with all the basic anthropometric measurements.

The basic statistics of physical ability tests results are presented in Table 1. The great variability of results demonstrates differences in the girls' physical development. The results correlate partially with age (see Table 1) and strongly with body build. The results of tests PA1 – PA5, PA8 and PA9 could be predicted by height and weight, as well as by models consisting of basic anthropometric measurements within approximately 30–80%.

The results indicate that, when establishing norms for young female volleyball players' physical development, individual body structure should be taken into consideration (Stamm, et al., 2002).

The basic statistics of volleyball technical tests results are presented in Table 2. Here, too, the great variability of the girls' technical skills is revealed. The results did not correlate with age and showed partial correlation (T2, T3, T4, T6, T7) with body build (R2 = 0.18 – 0.29).

The results of psychophysiological tests are presented in Table 3 (see page 54). The great variability of results confirmed the girls' different reaction to speed perception, auditory and visual stimuli and anticipatory reaction to reality. Ten tests showed stronger correlations with body build than the others (r = 0.3 – 0.4), but age had no influence on test results.

We conducted an additional study of mutual correlations between test results and found that nearly all physical ability tests, volleyball technical tests and psychophysiological tests were in significant statistical correlation (r = 0.3 – 0.4).

As most of the tests also correlated with body build, one may conclude that body build and different abilities form one whole that should be taken into consideration as such.

In addition to the tests, in 32 players out of 46, proficiency at competitions was assessed by the program Game. All the anthropometric characteristics and test results of these 32 girls were correlated with the index of proficiency for all elements of the game. From the anthropometric variables and test results that significantly correlated with proficiency in the game, we calculated by means of stepwise procedure the best models of linear regression for predicting proficiency in different elements of the game. The results are presented in Table 4 (see page 55).

Here we can see that different kinds of tests were essential for proficiency in the game. There were 14 anthropometric characteristics that proved to be essential for proficiency in the game. These were height, weight, xiphoidal height, suprasternal height, chest, waist and hip circumferences, relaxed arm circumference and flexed and tensed arm circumference, upper thigh and lower leg circumference, wrist circumference and wrist breadth. Proficiency in the game was determined by these variables within 32–83%. Among physical ability tests, 4 tests were essential (endurance, flexibility, speed and medicine ball throwing tests). Among volleyball technical tests, 5 tests out of 9 were essential for proficiency in the game.

Table 2

Basic statistics of young female volleyball players' (n = 45) volleyball technical skills tests*

No	Variable	$\bar{x}$	SD	Min	Max
1	Overhead pass with a clap behind the back T_1	16.58	5.56	2.00	20.00
2	Overhead pass with squat T_2	7.31	4.89	2.00	20.00
3	Forearm pass into 1 m^2 T_3	21.40	11.69	1.00	30.00
4	Spike along the sideline T_4	4.49	2.04	0.00	8.00
5	Spike diagonally T_5	3.93	1.50	0.00	7.00
6	Feint into the centre of the court T_6	4.11	1.82	0.00	8.00
7	Serve straight T_7	5.33	1.85	0.00	8.00
8	Serve diagonally T_8	5.20	1.63	2.00	8.00
9	Reception into zone 2 or 3 T_9	5.02	1.71	2.00	8.00

* The tests measured the number of successful repetitions in points

Table 3
Basic statistics of young female volleyball players' psychophysiological tests results (n=32)

No	Variable n=32	x	SD	Min	Max
1	Average score of first-time speed perception tests (in points) A_1	4.341	4.072	-8.000	10.000
2	Average reaction time in first-time speed perception tests (sec) A_2	0.697	0.240	0.210	1.880
3	Average score of second-time speed perception tests (in points) A_3	6.049	2.881	0.000	12.000
4	Average reaction time in second-time speed perception tests (sec) A_4	0.691	0.160	0.500	1.270
5	Average score of third-time speed perception tests (in points) A_5	2.878	2.685	-2.000	12.000
6	Average reaction time in third-time speed perception tests (sec) A_6	0.790	0.142	0.580	1.440
7	Average reaction time in first-time auditory perception tests (right hand) (sec) B_1	0.235	0.064	0.169	0.447
8	Average reaction time in first-time auditory perception tests (left hand) (sec) B_2	0.229	0.061	0.175	0.452
9	Average reaction time in second-time auditory perception tests (right hand) (sec) B_3	0.209	0.053	0.119	0.387
10	Average reaction time in second-time auditory perception tests (left hand) (sec) B_4	0.213	0.057	0.125	0.429
11	Average reaction time in third-time auditory perception tests (right hand) (sec) B_5	0.216	0.043	0.160	0.368
12	Average reaction time in third-time auditory perception tests (left hand) (sec) B_6	0.212	0.047	0.110	0.374
13	Average reaction time in first-time visual perception tests (right hand) (sec) C_1	0.199	0.060	0.129	0.364
14	Average reaction time in first-time visual perception tests (left hand) (sec) C_2	0.200	0.060	0.121	0.369
15	Average reaction time in second-time visual perception tests (right hand) (sec) C_3	0.200	0.076	0.101	0.495
16	Average reaction time in second-time visual perception tests (left hand) (sec) C_4	0.197	0.078	0.069	0.501
17	Average reaction time in third-time visual perception tests (right hand) (sec) C_5	0.197	0.050	0.107	0.326
18	Average reaction time in third-time visual perception tests (left hand) (sec) C_6	0.197	0.048	0.100	0.319
19	Anticipatory reflection of reality, first attempt (sec) D_1	0.494	0.228	0.002	1.541
20	Anticipatory reflection of reality, second attempt (sec) D_2	0.483	0.182	0.103	1.059
21	Anticipatory reflection of reality, third attempt (sec) D_3	0.586	0.155	0.281	1.237

Table 4
Linear models for young female volleyball players' efficiency of perfomance different technical elements by anthropometric measurements and results of tests of physical, psychophysiological and volleyball technical abilities (n=32)

No	Predicted variable	Regression equations and coefficients of determination			
		Anthropometric basic measurements	Physical ability tests	Volleyball technical skills tests	Psychophysiological properties
1	Efficiency of serve	$-0.99-0.02X_2-$ $-0.03X_3+0.06X_5+$ $+0.09X_{36}$ $R^2=0.32$	none	none	none
2	Efficiency of reception	$3.36+0.03X_2-0.09X_5+$ $+0.08X_4+0.55X_{24}-$ $-0.02X_{27}-0.13X_{39}$ $R^2=0.50$	$2.10-0.0008PA_5+$ $+0.009PA_7-0.05PA_8$ $R^2=0.44$	$-0.24+0.01T_2+0.03T_6$ $R^2=0.39$	$0.76+0.03A_3-2.24B_6$ $R^2=0.39$
3	Efficiency of block	$-3.48+0.07X_2+$ $+0.06X_3-0.16X_{32}$ $R^2=0.80$	none	none	$0.79+0.15A_3+0.08A_5-$ $-12.27B_3+4.94B_6$ $R^2=0.98$
4	Efficiency of feint	$-3.22-0.05X_2-$ $-0.06X_3+0.11X_5-$ $-0.07X_{29}+0.03X_{31}+$ $+0.19X_{36}$ $R^2=0.83$	$0.34+0.0009PA_5$ $R^2=0.18$	$0.20+0.09T_8$ $R^2=0.44$	$1.33+0.04A_5-3.74B_6$ $R^2=0.60$
5	Efficiency of attack	$6.44+0.05X_2-0.03X_3-$ $-0.04X_{28}+0.12X_{35}-$ $-0.12X_{37}$ $R^2=0.71$	$0.06+0.002PA_9$ $R^2=0.22$	none	$1.07+1.61A_6-7.27B_4-$ $-0.68D_2$ $R^2=0.80$

Exploratory variables:
X2 – Weight (kg)
X3 – Height (cm)
X4 – Suprasternal height (cm)
X5 – Xiphoidal height (cm)
X24 – Wrist breadth (cm)
X27 - Upper chest circumference (cm)
X28 – Lower chest circumference (cm)
X29 – Waist circumference (cm)
X31 – Hip circumference (cm)
X32– Upper thigh circumference (cm)
X35 – Lower leg circumference (cm)
X36 – Arm circumference (cm)
X37 – Arm circumference flexed and tensed (cm)
X39 – Wrist circumference (cm)
PA5 – Endurance shuttle run test (sec)
PA7 – Flexibility test (sit and reach) (cm)
PA8 – Speed shuttle run test (sec)
PA9 – Medicine ball throwing test (cm)
A3 – Average score of second-time speed perception tests (in points)
A5 – Average score of third-time speed perception tests (in points)
A6 – Average reaction time in third-time speed perception tests (sec)
B3 – Average reaction time in second-time auditory perception tests (right hand) (sec)
B4 – Average reaction time in second-time auditory perception tests (left hand) (sec)
B6 – Average reaction time in third-time auditory perception tests (left hand) (sec)
D2 - Anticipatory reflection of reality second attempt (sec)

The most essential for proficiency in the game were the psychophysiological tests, which predicted proficiency in the elements of game that needed quick reaction (block, feint and attack) within 60–98%.

CONCLUSION

The present study indicates that, in order to increase 13–16-year-old female volleyball players' proficiency, the players' all-round individual development is necessary in order to improve the level of their physical, technical and psychophysiological abilities.

The regular system of body build, the correlation of basic anthropometric measurements with test results, as well as with proficiency at competitions, shows that we have to do with one constitutional whole which also requires integrated assessment.

IMPLICATIONS FOR COACHING

In everyday work with this age group, along with development of routine playing skills, more attention should be paid to the development of the players' physical abilities and certain psychophysiological properties.

In order to get a more complete and comprehensive picture of 13–16-year-old female volleyball players' development, they could be tested during annual championships. The number of anthropometric measurements could be somewhat smaller than in the current study, but they should definitely include these 14 variables that showed significant correlation with proficiency in the game. The tests should include physical abilities, as well as psychological properties tests, perhaps to a somewhat smaller extent. In order to assess proficiency in the game, the standardized computer program Game could be used. Data should be entered into a special computer program that would enable an annual comparison of the development individual players, as well as teams.

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Raini Stamm is a professor in the Department of Physical Culture at the University of Tartu, Estonia.

The Spike, Attack Zones and the Opposing Block in Elite Male Beach Volleyball

Isabel Mesquita and José Teixeira, University of Porto (Portugal)

Identification and association with the type of spike, the attack zones and the type of block opposition in world elite male beach volleyball teams (BV) were investigated. All told, 676 spikes were analyzed from a group of 27 sets and 12 games of teams positioned in the top 20 world teams (FIVB ranking, 2000). The variables of analysis focused on the type of spike, attack zones and type of opposition block (with and without block). Descriptive statistics were applied to obtain frequencies and their respective percentages and inferential statistics in the calculation of the Chi-Square test. In the reliability analysis, the minimum percentage value was 83.9% (inter-observer) relative to the variable type of attack and the maximum of 100% in the variable type of opposition block (intra-observer and inter-observer). The present study showed that the spike is more frequent than the shot; associations identified between the type of spike and attack zones and between the type of spike and the opposing block.

Key words: game analysis; beach volley; attack

La présente étude a été prévue pour identifier et associer le type de transitoire aux zones d'attaque et le type d'opposition de bloc dans les équipes masculines de volleyball de plage d'élite du monde (BV). Un total du groupe de 676 transitoires de 27 ensembles et de 12 jeux, des équipes a placé dans les 20 équipes principales du monde (rang de FIVB, 2000). Les variables de l'anaylsis se sont concentrées sur le type de transitoire, les zones d'attaque et le type de bloc d'opposition (avec et sans le bloc). Des statistiques descriptives ont été employées pour obtenir les fréquences et leurs pourcentages respectifs, et les statistiques déductives dans le calcul de la Chi-Place examinent. Dans l'analyse de fiabilité la valeur de pourcentage minimum était 83.9% (inter-observateur) relativement au type variable d'attaque ; 100% dans le type variable de bloc d'opposition (intra-observateur et inter-observateur). La présente étude a prouvé que la transitoire est plus fréquente que le projectile. Des associations ont été identifiées entre le type de transitoire et les zones d'attaque et entre le type et le bloc d'opposition.

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INTRODUCTION

Beach volleyball (BV) has developed substantially in the last couple of decades, changing progressively from a sporting leisure activity to a professional one (Lacerda, 2000). Despite this development, the literature that is available has been insufficient; studies related to the characteristics of the sport at a match analysis level and the actions of the players have also been rare.

REVIEW OF THE LITERATURE

In the attack context of BV, the spike is usually used as a fundamental offensive weapon, with most of the points being obtained through the application of this technique (Verdejo et al., 1994; Homberg & Papageorgiou, 1995; Fonoimoana, 1999; Kiraly & Shewman, 1999a; Smith & Kras, 1999; Lacerda & Mesquita, 2003). Although the technical and tactical demands of BV attack seem to be simpler in relation to indoor volleyball (IV), since the block opposition and the defense have just one player for each situation, the impositions brought about by the climatic conditions associated require the player to possess an enlarged technical repertoire, and impose specific competences adapted to the game problems.

Homberg & Papageorgiou (1995) refer that, by evaluating the tactical possibilities of the spike in BV and comparing them with IV, it is possible to distinguish two contrasting factors: one positive, since there is more free zone uncovered to drive the ball; and another negative, most notably the physical factors that hinder the perception of the ball movement (sun and wind) and decrease the application of power (sand).

In this way, the necessity which the player has to dominate the situational technique in relation with the tactical decision (Mesquita, 2000) is emphasized in BV by the interference of the climatic conditions (sun, wind,etc.) during the game (Palm, 1992; Wells, 1996; Kiraly, 1997; Kiraly & Shewman, 1999b).

This study identified the type of spike in relation to the attack zones and associated the type of block opposition for the teams positioned in the world top 20, in agreement with the FIVB ranking (2000) in beach volleyball. The following specific objectives were defined: identify the frequency of the type of attack; identify the frequency of the type of attack by attack zones; associate the attack zones with the type of attack; identify the frequency of the type of attack, according to the type of block opposition, with

and without block; associate the type of attack and the type of block opposition, with and without block.

METHODS

Sample

The sample of this study was taken from games of teams belonging to the top 20 in the world, according to the FIVB ranking of May 1, 2002. Six hundred seventy-six spikes from a group of 27 sets and 12 games were analyzed.

The teams that participated in the study are represented in Table 1.

Table 1: Teams belonging of the present study

Ranking	Teams	Country
1	Emanuel / Tande	BRASIL
2	Laciga / Laciga	SUIÇA
4	Ricardo / Loiola	BRAZIL
8	Heuscher / Kobel	SUIÇA
9	Zé Marco / Pará	BRAZIL
10	Prosser / Zahner	AUSTRÁLIA
12	Child / Heese	CANADÁ
13	Slack / Novosel	AUSTRÁLIA
15	Rodgers / Holdren	USA
19	Maia / Brenha	PORTUGAL

Films were collected during the events of Berlin (Germany), Lignano (Italy) and Vitória (Brazil), of the 2001 FIVB Beach Volleyball World Tour and the Beach Volleyball World Championship 2001 in Klagenfurt (Austria).

Variables of Analysis

-Type of Attack -

In BV it is possible to distinguish the spike (a ball contacted with force by a player on the offensive team who intends to terminate the ball on the opponent's floor or off the opponent's blocker) and the shot (placing a ball with a soft shot; offers best control, but doesn't facilitate the maximum extension) (Verdejo et al., 1994; FIVB, 1997; Kiraly & Shewman, 1999a).

On the shot attack, several variants have been distinguished:

•Loop or Rainbow: characterized by the timing of the contact with the ball. The attacker delays the moment of contact with the ball, therefore avoiding the block. The trajectory is similar to a parabola, going in the direction of one of the vertices of the field. It can be done in the diagonal or in parallel. Ideally, this shot will look the same as the cut shot, but at the last moment it is delivered not in a soft and short way, but in a high and deep way, in order to land just inside -- or, preferably, on -- the baseline. The idea is to draw the defenders in short, then "loop" the ball over their heads.

•Wrist Shot: characterized by the thrust given to the ball by the movement of the wrist. The trajectory is similar to a parabola, but in a short distance. It is so called because of the thrust given to the ball by the movement of the wrist. For this, it is necessary to extend the arm before the wrist movement, so that only the wrist does the movement.

•Cut Shot: the final part of the gesture is characterized by the movement of the wrist, contacting the ball laterally. The trajectory is diagonal and short, using closed angles (to make the defense's action difficult by diminishing the time of ball flight). zit is a soft, spinning shot intended to drop close to the net and the sideline. An intelligent player has a wide range of cut shots to keep opponents guessing. Sinjin Smith from the U.S. owed much of his brilliant career to developing cut shots that looked identical until the moment of contact, frustrating those who played against him.

•Pokey: contact with the ball by using the articulations of the fingers (knuckles) (used for the disputes of the ball on the net, or for correction of bad passes). Since using the fingertips to "tip" or push the ball is not allowed in beach volleyball, players use their knuckles instead. This is usually a soft shot played just over the net or blocker's hands.

•Cobra Shot: arm extended, contacting the ball with the fingertips (used for the disputes of the ball on the net, or to correct bad passes, taking advantage of the maximum height of the strike). It is when the fingertips or knuckles are used to strike the ball, using maximum extension of the arm. It is difficult to control because the straightened fingers are of different lengths.

- Attack Zones -

Three attack zones were considered, in accordance with the classification of Homberg and Papageorgiou (1995) and Lacerda (2002), in which the field is divided in 3 attack zones of identical dimensions, forming a square of 2.6m (see Figure 1): ZL- Left Zone; ZC-Central Zone; ZR-Right Zone.

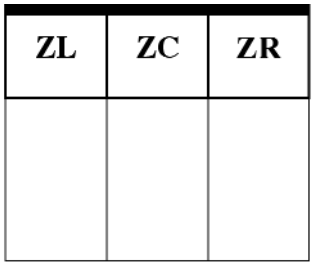

Figure 1: Attack Zones (ZL; ZC; ZR)

- Type of block opposition -

This variable was analyzed according to the number of blockers. In BV it is common to verify the existence of 1 blocker or no blocker (0) in opposition to the opponent's attack.

Data Collection

The observations were conducted so as to analyze the attacks when confronting teams could be made viable. Data were collected by a Sony DCR-TRV 325E video camera, with 8mm cassettes. The films were then transferred onto a VHS cassette format.

A Sony "Wide Conversion Lens" 0.6x VCL-0637H facilitated the increase of vision in reduced spaces, providing larger quality in the observation and reception of all the angles at short distances. The camera was placed in a position so as to observe and collect information on the spike and its effect on the opposite team.

Descriptive statistics were used to obtain the frequencies and percentages of the different variables. In the inferential statistics, we calculated the Chi Square test in contingency tables to assess the type of association between the different variables. The level of significance was kept at 5%. The statistical program used was SPSS 11.0.

To test the objectiveness of the observer, a second observation

of 2 games was done after 15 days by the same observers. For that, 143 spikes were analyzed, which corresponds to more than 20% of the totality of the sample. This is a substantially superior value to the minimum limit criteria reference pointed out by the literature of this speciality, which is 10% of the total of the sample (Tabachnick & Fidell, 1989).

The reliability of the intra-observer and inter-observer took place. The results obtained are above the limits specified by the literature of this speciality – that is to say, equal or superior to 80% (Van der Mars, 1989). The smaller percentage value found was 83.9% in the reliability of the inter-observer, in the variable of the type of attack. The highest value was 100%, in the number of block opposition, for the reliability of the intra-observer and inter-observer (Table 2).

Table 2 - Frequencies and Percentages of agreements, intra-observer (1) and inter-observer (2) reliability

1- Intra-observer	Observations number	Agreements	Disagreements	Agreements %
Attack Type	143	138	5	96,5%
Attack Zones	143	139	4	97,2%
Block Opposition	143	143	0	100%
2- Inter-observer	Observations number	Agreements	Disagreements	Agreements %
Attack Type	143	120	23	83,9%
Attack Zones	143	133	10	93%
Block Opposition	143	143	0	100%

RESULTS AND DISCUSSION

A) Frequency of Attack Type

Table 3 presents the frequency and respective percentages of the type of attack.

Table 3 - Frequency and respective percentages of the attack type

Attack type	Frequency	Percentage
Spike	392	58%
Rainbow	60	8,9%
Wrist Shot	101	14,9%
Cut Shot	95	14,1%
Pokey	28	4,1%
Total	676	100%

By analyzing Table 3, it is possible to verify that the spike is the more used type of attack in BV is the spike, which obtains the percentage value of 58%. This result is located between the values obtained by Homberg & Papageorgiou (1995), 53%, and Lacerda (2002), 59.7%.

BV suffered great alterations in the last years, including the game area, which was reduced (8x8m) (FIVB, 2000). The intention of this alteration was to attenuate the superiority of the attack over the defense, in order to facilitate a larger number of rallies with the increase of the sustainability of the ball and the spectacular tempo of the game. In our study, the percentage of the spike is superior to that of Homberg & Papageorgiou (1995), (59% and 53%, respectively), which was accomplished with the field's dimensions being 9x9m. This demonstrates the superior technical and tactical level of the attackers, who were able to obtain higher frequencies of spike with a more reduced space. This also suggests that nowadays, in BV, the high effectiveness in the attack is only possible through the players' adaptations in the style of the game, using different attack zones, faster trajectories in the set and in the thrust (Nichols, 1997; Sandorfi, 1998; Smith & Kras, 1999).

More used shot hits were the wrist shot (14.9%) and the cut shot (14.1%). The values of wrist shot contradict the results of the Lacerda study. While in Lacerda's study (2002) the wrist shot is the more used one (20.6%), in our study the value found was 14.9%. But in contrast to this, in the cut shot, Lacerda (2002) obtained 5.9%. The differences in the use of the wrist shot and the cut shot between our study and Lacerda's (2002) can be explained, fundamentally, by the characteristics of the opposite teams' attack, as well as by the players' style, but also, and not less importantly, by the climatic conditions in the location of the game. In fact, the interference of the climatic conditions (sun, wind, rain, etc.) and the characteristic of the physical space (characteristics of the sandy soil) can have an influence on how the game is played (Wells, 1996; Kiraly, 1997; Kiraly & Shewman, 1999b), not only in the decision making process, but also in the techniques chosen to solve the problems in the games.

The frequency of the pokey attack was extremely reduced (4.1%), as was verified by Lacerda (4.2%), which can be due to its weak offensiveness in relation to the other types of shots. In fact, cut shots and wrist shots possess very short and descending trajectories, which in turn produce larger difficulties to the defense and, therefore, are used more than the pokey. This type of attack is used fundamentally in situations of proximity of the ball to the net and to the opposing field, with great difficulty to the attacker. Finally, the cobra shot did not have any occurrence in this study, as was seen in the investigation by Lacerda (2002).

B) Analysis of the Type of Attack in Relation to the Attack Zones

Frequency of attack in the different attack zones

Table 4 presents frequency and percentage of attack in the different attack zones.

Table 4 - Frequency and percentage of attack in the attack zones

Attack zones	Frequency	Percentage (%)
Left zone	262	38,8%
Central zone	148	21,9%
Right zone	266	39,3%
Total	676	100%

The more used attack zones were ZL (262 spikes, 38.8%) and ZR (266 spikes, 39.3%), the left and right sides of the field. Due to the reduced dimensions of the game area (8x8m), the BV players use the lateral zones in order to possess a larger attack space, as well as a better view of the opposing team's defensive movement. In this study, the relatively high use of the central zone (CZ – 21.9%) shows a high tactical intention of the players.

For several BV specialists (Homberg & Papageorgiou, 1995; Nobleman, 1997; Kiraly & Shewman, 1999a), the shot should be sufficiently well-placed so as to be indefensible – in other words, that it neither stays on the net nor out of the game area. The player should discover the opponent's weakest points and explore them (identify and dominate the zones of the field where an attack can be more effective) and develop the game vision (Lacerda & Mesquita, 2003).

When comparing other studies involving the attack zone in BV, it was verified that the values reached approach those reached by Homberg & Papageorgiou (1995) (ZE, 41%; ZC, 23%; ZD, 31%) and differ clearly to those reached by Lacerda (ZE, 49.9%; ZC, 3.5%; ZD, 46.6%). The greater difference is in the use of the central Zone (ZC), which in Lacerda's study (2000) was practically nonexistent. In this way, the attack zones were also preferred according to the physical conditions in which the games took place and the tactical players' options, according to the opponents' defensive characteristics (Palm, 1992; Wells, 1996; Kiraly, 1997; Kiraly & Shewman, 1999).

Association between the type of attack and the attack zones

Table 5 presents the frequencies and percentages of the type of attack, in the different variants, and its association with the attack zones.

Table 5 - Contingency table of association between type of attack and attack zones

Attack Zones		Spike	Rainbow	Wrist Shot	Cut Shot	Pokey	Total
Left Zone	Count	163	26	39	28	6	262
	Expected Count	151,9	23,3	39	36,8	10,9	262
	% Within attack zone	62,2	9,9	14,9	10,7	2,3	100
	% Within attack type	41,6	43,3	38,6	29,5	21,4	38,8
	Adjusted residual	1,8	0,8	0,0	-2,0	-1,9	
Central Zone	Count	74	10	31	21	12	148
	Expected Count	85,8	13,1	22,1	20,8	6,1	148
	% Within attack zone	50,0	6,8	20,9	14,2	8,1	100
	% Within attack type	18,9	16,7	30,7	22,1	42,9	21,9
	Adjusted residual	-2,2	-1,0	2,3	0,1	2,7	
Right Zone	Count	155	24	31	46	10	266
	Expected Count	154,2	23,6	39,7	37,4	11	266
	% Within attack zone	58,3	9,0	11,7	17,3	3,8	100
	% Within attack type	39,5	40,0	30,7	48,4	35,7	39,3
	Adjusted residual	0,1	0,1	-1,9	2,0	-0,4	
Total	Count	392	60	101	95	28	676
	Expected Count	392	60	101	95	28	676
	% Within attack zone	58	8,9	14,9	14,1	4,1	100
	% Within attack type	100	100	100	100	100	100

The statistical analysis allowed us to verify the existence of an association between the attack zones and the type of attack (__) =21,000 p=0.007; V Cramer=0.125).

Table 5 allows the following reading:

•In the left zone (ZL), the cut shot shows a negative contribution to the significant association found, since the frequencies obtained were inferior to the expected ones. However, spike and pokey show adjusted residual values, which approach the statistical meaning. The frequency obtained in the spike was superior to the expected one, and in the pokey, the contrary was verified. These results show, in an unequivocal way, that the left zone is marked sharply by the accomplishment of the spike (62.2%) in detriment to the shot (37.8%: 9.9% rainbow; 14.9% wrist shot; 10.7% cut shot and 2.3% pokey). In the cut shot, the wrist movement is very difficult for dextrous players, particularly when the attack is done in the left zone.

•In Zone C (central zone), the spike has a significant contribution, in a negative way, to the association found; the frequencies obtained were inferior to the expected ones. In fact, in this zone, the spike shows the lowest values (50%). The central zone offers the attacker a smaller thrust space in relation to the lateral zones, which explains why the spike is less used. In this zone and in the totality of the different variants, the shot was as used as the spike (50%), which shows the necessity with which the players have to use the shot as an effective offensive strategy of attack. The shot, the wrist shot and the cut shot show a significant contribution, in a positive way, with superior frequencies to the expected ones for both techniques. These two variants of the hit shot are preferentially used, either in attack situations, causing great difficulty to the surpassing of the block, or due to bad passes.

•In Zone R (right side of the net) only the cut shot has a significant contribution, in a positive way, to the association found; the frequencies obtained were superior to the expected ones. In fact, it was in this zone that the cut shot had superior frequencies, perhaps due to being a difficult zone in the attack (both for the difficulties imposed to the set and to the hit) and to the necessity which the players have to use a technique capable to minimize the mistake, giving offensiveness to the attack. The cut shot is easier because the wrist movement favors the trajectory. The wrist shot presents adjusted residual values, which approach the statistical meaning, the frequencies being inferior to the expected ones. This variant of the shot is difficult to execute, as it consists of a thrust given to the ball starting from the movement of the wrist (Verdejo et al., 1994; Shewman, 1999a).

These results demonstrate a relationship between the zone from where the attack is conducted and the type of attack; the tendency for the spike to be conducted is more prevalent in the lateral zones of the net, while the hit shot originates more in the central zone

(ZC). In the hit shot, the technical variants seem to show a better adjustment to some zones than to others. While the cut shot is more frequent on the right side (ZR) of the net, the wrist shot thrust is used more in the central zone (ZC) and on the left side (ZL).

The rainbow shot is more frequent in the lateral zones (ZL and ZR) in relation to the central zone (ZC). The rainbow shot is characterized by the timing of the contact with the ball so that the attacker can delay the moment of contact and drive the ball to one of the vertices of the field (Verdejo et al., 1994; FIVB, 1997; Kiraly & Shewman, 1999a). It is a high strategy attack in difficult situations.

C) Analysis of Type of Attack in Relation With Block Opposition

Frequency of attack in relation with block opposition

Table 6 presents the frequency and respective percentages of the type of attack in relation with block opposition (without block or one blocker).

Table 6 - Frequency and percentage of attack in relation with block opposition

Block opposition	Frequency	Percentage
One blocker (1)	572	84,6%
No blocker (0)	104	15,4%
Total	676	100%

By analyzing Table 6, it is possible to verify that most of the attacks are accomplished in the presence of the block (84.6%). Homberg & Papageorgiou (1994) determined that at a highly competitive level of BV, 11% of all the blocks are "fake blocks"; that is, the player at the net retreats to defend, leaving the attacker without opposition at the net. In our study, 15.4% of attacks were made without block, which can be explained by the tactical defense adopted by the opponent team in relation to the characteristics of the opposing team's attack. The high percentage value of the attack made with the block opposition demonstrates the great technical domain and the tactical capacity of the players in this study, and at the same time in the lower defense, only one player remains.

The association between type of attack and block opposition

Table 7 presents the frequencies and percentages of the type of attack and its association with the opposition block.

The statistical analysis verified the existence of a significant association between the type of attack and the block opposition (__) = 8.284; p = 0.051; V Cramer = 0.111), the cells of the spike and the cut shot having contributed to this association.

Based on Table 7, the following considerations can be made:

•Relative to the attack without block opposition, the spike makes a negative significant contribution, showing lower frequencies to the expected ones; however, the cut shot has a positively significant contribution, with higher frequencies to the expected ones.

•Relative to the attack with block opposition (one blocker), the contrary was determined. The spike had a significantly positive contribution, with superior frequencies to the expected ones; the cut shot had a significant contribution, in a negative way, with lower frequencies to the expected ones.

These results show the influence of defense conditions (presence or absence of block) with the type of attack used. While the spike was used more with the block (59.6%), and less without block (49%), the hit shot (in the totality of the variants) was used more without the block (51%) and less with the block (40.4%).

Different variants, however, were used in more or less frequency, depending upon the existence (or lack of) the block. When there was no block, the variant was the cut shot followed by the wrist shot, whereas with the block, the wrist shot is used more than the cut shot. The rainbows and poke variants were always used less, and the latter was lesser used.

At the BV elite level, the block-defense system formed a coherent and very effective unit, which obligates the attacker to use different variants of attack, in agreement with the conditions of the block opposition and defense's position (Homberg & Papageorgiou, 1995; Tanner, 1998). Only through the use of a high variety of attack techniques is it possible for the attackers to surpass the block and place the ball in the most appropriate space.

CONCLUSION

The results from this study support the following conclusion:

•The spike was the most frequent attack (58%);

•The shot (42%), the wrist shot and the cut shot (14.9% and 14.1%, respectively), was the most frequent attack;

Table 7 - Contingency table of association between type of attack and block opposition

Block opposition		Spike	Rainbow	Wrist Shot	Cut Shot	Pokey	Total
No Blocker	Count	51	7	20	22	4	104
	Expected Count	60,3	9,2	15,5	14,6	4,3	104
	% Within block opposition	49,0	6,7	19,2	21,2	3,8	100
	% Within attack type	13,0	11,7	19,8	23,2	14,3	15,4
	Adjusted residual	-2,0	-0,8	1,3	2,3	-0,2	
One Blocker	Count	341	53	81	73	24	572
	Expected Count	331,7	50,8	85,5	80,4	23,7	572
	% Within block opposition	59,6	9,3	14,2	12,8	4,2	100
	% Within attack type	87,0	88,3	80,2	76,6	85,7	84,6
	Adjusted residual	2,0	0,8	-1,3	-2,3	0,2	
Total	Count	392	60	101	95	28	676
	Expected Count	392	60	101	95	28	676
	% Within block opposition	58	8,9	14,9	14,1	4,1	100
	% Within attack type	100	100	100	100	100	100

•The more used attack zones were the lateral zone, left and right zones (38.8% and 39.3%, respectively). However, Zone C registered a considerable frequency of attack (21.9%);

•The attack zones interfered with the type of attack. The existence of a significant association was verified between the type of attack and the attack zones. The cut shot on the left zone and the spike on the central zone (ZC) contributed negatively to this association (with inferior frequencies to the expected ones), whereas the wrist shot and the pokey in the central zone (ZC) and the cut shot in the right zone contributed positively (with superior frequencies to the expected ones).

•The situation with block opposition (84.6%) was more frequent.

•The block opposition interfered with the type of attack. The existence of a significant association was verified among the type of attack and the block opposition. The spike without block and the cut shot with block opposition contributed negatively to this association (with inferior frequencies to the expected ones) and the spike with block opposition and the cut shot without block contributed positively (with superior frequencies to the expected ones).

IMPLICATIONS FOR COACHES

The spike attack is the most used by elite athletes. Training should always focus on this type of attack, hiding the possibility of the ball placement until the last moment.

There is a tendency to use some attack zones more than others, according to the type of attack. Athletes should possess a variety of solutions for the challenges in the game, using all the zones and types of attacks available (not forgetting the strong points and the regularities of the game).

The block is almost always present when attacking. The athlete should know how to explore the opposing team's block. Indeed, the distinguishing factor between the teams is the capacity to exploit the block in relation to the use of the type of attack.

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Isabel Mesquita is an associate professor in the Faculty of Sport Sciences and Physical Education at the University of Oporto, Portugal. She is responsible for the Volleyball Department.

José Teixeira has a degree in physical education from the Faculty of Sport Sciences and Physical Education at the University of Oporto. He is also a volleyball professor in ISLA, Bragança, Portugal. Teixeira is a beach volleyball player and was the European champion in the under-23 category in 2001.

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2004 Accepted Research Consortium Volleyball-Related Abstracts

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An Examination of Alcohol Use Among College Athletes

Jason Kueffler and Jon Lim, Northern State University

Binge drinking has been identified as a major problem plaguing colleges across America. The purpose of this study was to examine the alcohol usage rates of college athletes and non-athletes, their motives for alcohol use, perceptions of alcohol use by their peers, and alcohol consumption based on selected demographic characteristics. Participants (N=208) were composed of 121 student-athletes and 87 non-athletes from a midsize midwestern university. The student-athlete group consisted of athletes from men's and women's track and field (n = 36), men's and women's basketball (n = 20), volleyball (n = 13), soccer (n = 12), softball (n = 11), baseball (n = 14) and wrestling (n = 15). The participants completed a 20-item questionnaire assessing their alcohol usage rates, their perceptions of alcohol use by their peers, and their motive for using alcohol. All items were modified from previous studies and validated for this study. The results of this study indicated the athlete group had a significantly higher rate of alcohol use than non-athletes, $t = -.947$, $p < .05$. The finding was supported by previous studies (Moulton, et al., 1999). However, the athletes perceived that non-athletes used alcohol more often than did athletes. Most of the participants reported that their main reason for alcohol use was recreational or social purposes, which was more inline with findings of NCAA drug and alcohol survey in 2001. Wrestlers had a significantly higher rate of alcohol use than volleyball players over the past 12 months and a significantly higher rate of alcohol use than volleyball, softball and track over the past 30 days. However, this study also found that male athletes had a significantly higher rate of alcohol use than female athletes, which may attribute to the difference of wrestlers and the other female sports.

Disordered Eating Patterns in Adolescent Female Volleyball Players

Julio Morales, Lamar University, and Jimmy Disch, Alison Broadfoot, and Leigh Leman, Rice University

With the implementation of Title IX, more female athletes than ever are competing at the collegiate level. Because of this, there has been an influx of female adolescents participating in club sports in hopes of obtaining a scholarship. This study focused on the implications of increased pressures from parents, coaches, and the players themselves, especially the increased presence of disordered eating among female adolescent volleyball players. The purpose of this study was to see if female adolescent volleyball players were more likely to exhibit disordered eating patterns than normals. In this study, the participants completed the Eating Disorder Inventory survey by Garner, Olmsted, and Polive, which includes 11 sub-scales. Participants were 20 adolescent female volleyball players, ranging in age from 14 to 18 years. They came from high schools in and around the greater Houston area, and participated in junior club volleyball. Each athlete was informed that she was not required to participate and could stop at any time. An independent samples one-tailed t-test was completed to compare the 20 female volleyball players in this study to a normative group. The normative data was obtained from Garner's research findings. It included 675 non-patient, adolescent, female participants. The t-test indicated the volleyball players scored significantly higher on perfectionism when compared to the normative group [$t(693) = -4.58$, $p < .001$]. It was also found that as age increased, so too did scores on most sub-scales in the EDI II. These findings suggest an increase in disordered eating as these athletes mature. Coaches should be aware of this when working with female athletes of this age level.

Eating Disorders in Female Collegiate Athletes and Non-Athletes

Nikki VonSeggern and Jon Lim, Northern State University

The increasing number of studies over the past decade has shown that female athletes are at a high risk for developing eating disorders (McNulty, Adams, Anderson & Affenito, 2001; Picard, 1999). However, some recent studies have found that athletes are not at a greater risk for developing eating disorders (Carter, 2002; Davis & Strochan, 2001). In addition, the majority of the previous studies were done at an NCAA Division I setting. Therefore, the purpose of this study was to examine eating attitudes in relation to eating disorders among undergraduate female athletes and non-athletes at an NCAA Division II university. Also, this study examined the prevalence of eating disorders among female athletes based on certain sports, and determined relationships between eating disorders and a number of variables, such as self-esteem, body image, social pressures, and body mass index (BMI), that are thought to contribute to eating disorders. A total of 132 students was utilized for the research and consisted of 60 athletes and 65 non-athletes. The athletes were softball (n = 11), soccer (n = 12), track (n = 8), cross-country (n = 5), basketball (n = 9), and volleyball (n = 15). The Eating Attitudes Test (EAT-26) was used to determine who may be at a higher risk for the development of eating disorders or who may actually have an eating disorder. Participants who scored 20 or above on the EAT-26 were considered to be at a higher risk. The results of this study showed that less than 1% of the participants scored 20 or above. No significant difference exists in eating attitudes in relation to eating disorders between athletes and non-athletes. Also, this study found no significant differences in eating disorders between sports. Additionally, no significant relationships were found between eating disorders and self-esteem, social pressures, body image, and BMI. Some of the findings were inconsistent with previous findings, which may be due to less pressure from coaches and teammates in a Division II school. Picard (1999) found that the demand to perform well is stronger and there is more pressure in Division I ath-

letics, which may result in a higher risk for developing eating disorders in Division I athletic teams than Division II athletic teams. However, more research needs to be done in this area. Future studies should also look at how much impact coaches have on the development of eating disorders in their athletes.

Analysis of the Undergraduate Physical Education Teacher Certification Activity Requirements Within the United States

Carl P. Bahneman and John C. McGrath, West Virginia University

There has been much legislation and numerous education projects directed toward curriculum reform. Recently, "America 2000" gave a vision of American education. What is it that a student should learn in public school physical education? Recently, various constituencies have agreed on the content and process of measuring youth fitness (Fitness Gram). Freeman, 1997 and others state that the theoretical bases of physical education are sport, movement and fitness. The authors suggest that the lack of agreement among professionals and among programs causes a constant state of ambiguity and uncertainty. For example, should every public school student know about and be able to perform certain sport and movement skills as is currently agreed upon relative to youth fitness? The purpose of this study was to identify and enumerate the "physical education teacher education" certification program activity requirements within colleges and universities throughout the United States. The graduates from these programs will be the future public school physical educators. It is assumed that substantial agreement among programs regarding activity requirements will be a starting point to begin making some decisions about what is essential regarding sport, movement and fitness content. Within the United States, 537 institutions were identified as having physical education programs (Human Kinetics, 1987). One-half of these institutions (268) were randomly selected to participate in this study. Complete sets of curricular materials were obtained from each of the participating institutions. Of the 268 institutions solicited, 180 (67%) participated in this study. From the materials received, all sport, movement and fitness activities were listed by occurrence (number of institutions which require the activity), credit hours assigned to the activity, and percent of institutions which require the activity. The data show that 49% or more of the participating programs require the following 12 activities: aquatics, badminton, basketball, field hockey, golf, gymnastics, softball, team handball, track and field, volleyball, wrestling and football (flag or touch). Movement skills (i.e., locomotor skills, manipulative skills, etc.) were required by all (100%) of the participating programs. The credit hour requirement, however, ranged from 1 to 3. The data which were most surprising showed that fewer than half of the institutions required any type of fitness activity. Although there is some agreement among institutions relative to requiring sport, movement and fitness activities in teacher preparation programs, the lack of agreement about essential content is of great concern.

Examination of Expert and Novice Volleyball Coaches' Diagnostic Ability

Wei Bian, University of Northern Iowa, and Paul G. Schempp, University of Georgia

Sport-skill diagnosis is a complex process, which depends on the command of a large body of domain-specific knowledge that allows coaches to find solutions for technique deficiencies. Information from research on the diagnostic processes of coaches has the potential for practical applications to technique training and skill assessment. Additionally, it will help novice coaches and preservice physical educators to develop instructional strategies and diagnostic ability of motor skill. The purpose of this study was to examine expert and novice volleyball coaches' diagnostic ability of a volleyball skill. Four expert and 4 novice high school volleyball coaches participated in this study. Research procedures included an interview, a recall test, and the diagnostic task where the coaches analyzed the volleyball spike performance. Transcripts of both coaches' verbal and nonverbal reports were sent to coaches for a member check, and used for data analysis. Results revealed that there were differences in diagnostic ability between expert and novice volleyball coaches. Expert coaches' knowledge regarding the volleyball spike was richer and more extensive than that of novices in a) the number of the components identified, b) the number of body parts used to describe the skill, and c) in the judgment as to which issues are most critical in skill execution. Expert coaches' explanations about an ideal spike demonstrated the knowledge that was more technically specific, and procedure-oriented, which may have been enhanced by their years of successful coaching experience. Expert coaches' recall statements were more evaluative and technique-related. Although both expert and novice coaches reported a similar number of information cues during the skill diagnosis, experts perceived a greater number of technique deficiencies as compared to the novices. Findings from the present study also indicated the connections between coaches' knowledge of the volleyball spike and their diagnostic ability. The study shows there is a need for novices to develop their motor skill diagnostic competency, not only from classroom study, but also from field experience.

Lesson Preparation: How Teachers' Planning Affects Students' Behaviors

Rachel Gurvitch and Andrew Hawkins, West Virginia University

How best to prepare physical education students for their first teaching experience is still debatable. This research specifically addresses the issue of lesson preparation. The effects of planning on teachers' behaviors have been examined in the past (e.g., Peterson, Marx, & Clark, 1978). Imwold et al. (1984) found that planning had an effect on teaching behavior when comparing teachers who planned their lessons to those who did not. Twardy and Yerg (1987) concluded that planning promoted active teaching behaviors among teachers. In the same vein, the present research studied the effects of lesson planning on the behaviors of teachers and students under 2 planning conditions: a) self-made (SM), and b) ready-made (RM) lesson plans. Following the same lesson objectives, RM plans were given to preservice teachers 1 week prior to their teaching day, whereas SM lessons had been planned by the preservice teachers. An alternating treatment

design was used to examine 18 physical education majors who had no previous teaching experience as they taught soccer and volleyball units to 3rd grade students. Teaching episodes were videotaped and assessed using an ALT-PE based instrument. Visual analysis of the graphic data was used to analyze the relationship between planning conditions and behaviors. No significant differences between planning conditions with regard to student waiting and cognitive or teacher verbal instruction were found. However, significant differences were found in favor of SM lesson plans with regard to student motor-appropriate and off-task behavior. Similar to Byra and Coulon (1994), these results indicated that engagement in planning has a positive effect on the students' behaviors of preservice teachers. When preservice teachers used their own plans, their teaching was more successful in maximizing time students were engaged in a motor-appropriate activity and in minimizing time they were engaged in an off-task behavior. As opposed to other studies which investigated the effects of planning versus non-planning by preservice teachers, this study utilized nationally validated SPARK curriculum as the source for RM plans in addition to preservice teachers' SM plans. Nevertheless, the SM lesson plans produced better teaching practices. The main recommendation for teacher educators was to provide preservice teachers with more SM planning opportunities in order to encourage better teaching practices during preparation programs. Future research should examine preservice teachers' affective domain in order to complement the findings of this study and demonstrate how the planning process affects preservice teachers' feelings, thoughts and beliefs.

Use of Web-Based Portfolios in College Physical Education Activity Courses

Oleg A. Sinelnikov and Peter A. Hastie, Auburn University

Traditional assessment practices in college activity courses typically involve paper-and-pencil type activities (written exams, essays, papers) augmented with applicable skills tests. In addition, grading in college physical education has not been very rigorous, focusing on attendance, effort, and participation. Historically, it appears that students' perception of collegiate physical education courses is "show up, try hard, and get an easy A." Initial attempts of combining portfolios and sport education have shown considerable alignment between students' perceptions of and experiences with completing team portfolios and the purposes and outcomes of sport education (Kinchin, 2001). Current technological advances offer exciting and new venues for the development of authentic assessment. One route appears to be in the direction of web-based group portfolios. The purpose of this study was to describe and evaluate the introduction of web-based team portfolios within the context of collegiate physical education classes. During the course of 3 sport education volleyball seasons, teams were required to design and maintain a team Web site, including entry page, statistics, biographies, commitment, coach's corner, and game reports. Students designed, published, and updated the Web pages according to their team roles (e.g., statistician, reporter, coach). The team Webmaster was responsible for overall guidance. Two data sources were used in this study; analysis of Web pages and questionnaires. Four independent evaluators examined the Web pages of 5 randomly selected teams and used a grading criterion to compare Web contents with the objectives of sport education. At the end of the semester, students completed a 6-item questionnaire with open responses concerning their enjoyment, affiliation, and learning how to develop and publish Web pages. The results demonstrated that the Web sites strongly captured the objectives of the sport education model. Independent experts agreed that the Web sites depicted all 6 characteristics of the sport education model (seasons, culminating event, affiliation, record keeping, festivity, and formal competition). From student responses, 5 main themes developed: "development of team collegiality," "we've never done anything like this before -- anywhere in college," "too much work for physical education," "picking up teammates' slackness," and "the need for additional time within the time frame of the class." These data suggest that the development of group portfolios in the form of team Web sites positively contribute to the objectives of the sport education and raise the sophistication of authentic assessment. While the results of using Web-based group portfolios are encouraging, further descriptive investigation is warranted with respect to students' perceptions of activity courses.

Investigating Situational Interest in High School Physical Education

Prithwi Raj Subramaniam and Sarah Doolittle, Hofstra University

The purpose of this study was to examine situational interest and its congruence from the teacher and students' perspectives. Students from 2 different class contexts (large 9th and 10th grade, and small 11th and 12th grade classes) and their physical education teacher (37 years experience) were the participants in this study. In the volleyball unit, class size was large (n = 35 students), and in the pickleball unit class size was small (n = 18 students). Quantitative and qualitative methods were employed in data collection. First, students' interest in the unit was assessed through a questionnaire. Second, non-participant field notes were taken every other lesson. Third, teacher and students were formally interviewed. All interviews followed an interview guide approach (Patton, 1990) and were structured around topical areas representing the purpose of the investigation. Fourth, informal interviews also were conducted with the teacher. Descriptive analysis followed by dependent t-test was conducted on the survey data. Qualitative data analysis was continuous and employed procedures recommended by Denzin and Lincoln (1994). Survey data indicated no significant difference in mean student scores from pre to post for the volleyball class, $t(27) = 1.56$, $p = .129$, and the pickleball class, $t(18) = 1.55$, $p = .137$, respectively. The pre to post scores for gender also was not significant for the volleyball class $t(11) = 1.81$, $p = .129$ (females), and $t(15) = 1.82$, $p = .088$ (males), and the pickleball class $t(5) = 1.81$, $p = .129$ (females), and $t(12) = .56$, $p = .57$ (males), respectively. Student interview data indicated very little personal interest in the activity after completion of the unit. Neither skill level nor gender played a major role in personal interest. Observations and teacher interviews yielded a variety of teaching strategies deliberately planned to stimulate interest. Despite the teacher's effective use of a variety of strategies consistent with the "catch" facet of situational interest, data did not reveal an increase in student interest. Mitchell (1993) suggests stimulating interest without addressing

conditions that make content personally meaningful, and empowering students as active participants in the learning process could impact personal interest in the activity. Overemphasizing the "catch" facets and downplaying the "hold" facets of situational interest in the learning environment may be part of the explanation for the lack of meaning from the students' point of view in this investigation.

Understanding Head Coaching Behavior Among Female NCAA Assistant Coaches

Michael Sagas and George B. Cunningham, Texas A&M University-College Station, Donna L. Pastore, The Ohio State University, and Scott Waltemyer, Texas A&M University-College Station

The decline in the proportion of females from the ranks of college coaching has been well documented and researched in the literature. However, a dearth of studies has identified career and work-related factors from assistant coaches of women's teams that may elucidate reasons for this decline. The importance in studying the women's team assistant coach lies in the fact that females comprise many of these positions (56.4%), and thus constitute a large pool of candidates for head coaching positions -- a group in which females occupy a minority of positions (44%) (Acosta & Carpenter, 2002). It is equally important to study females in assistant coaching positions, since a study completed by Sagas, Cunningham, and Ashley (2000) has indicated that (a) female assistant coaches were less active in applying for head coaching positions than males and (b) they have less desire to do so in the future. The aims of this study were twofold. First, in employing the Theory of Planned Behavior (Ajzen, 1991), we sought to examine the extent to which attitudes, subjective norm, and perceived behavioral control impacted the intentions of female assistant coaches to apply for a head coaching position. Second, we aimed to establish the most important factors (i.e., belief-based measures) in predicting the intention to become a head coach. A researcher-developed questionnaire was sent to assistant coaches from the 4 largest women's team sports: softball, basketball, soccer, and volleyball (N = 2080; 520 per sport). Preliminary analyses (n= 188) of female assistant coaches in the sports of volleyball and soccer provided support for the Theory of Planned Behavior as a predictor of head coaching intentions. After controlling for age, previous applications, and occupational tenure, the 3 direct measure variables explained 63.2% of the variance in intentions. A number of the belief-based measures were also significantly related to head coaching intentions. Specifically, all of the normative belief variables (former coaches, friends, family, coaching peers, former players, current players, and current head coach) were positively correlated to head coaching intentions. Six of the attitude variables were also positively correlated with intentions (philosophy, control, role model to players, recognition, developing new skills, and decision making latitude). However, none of the behavioral control belief based variables were related to intentions. These preliminary results have produced a theoretical understanding of head coaching intentions among female coaches. Further, the significant belief-based measures have provided supporting paths toward intentions that need to be maximized in practice.

Social Interactions and Academic Learning Time-Physical Education (ALT-PE) in Inclusive General Physical Education: A Case Study

Iva Obrusnikova and Martin Block, University of Virginia

The purpose of this research focused on 2 distinct questions. First, what were the frequencies and types of social interactions of a 4th grade student with a disability (a child with muscular dystrophy who uses a wheelchair) in a general physical education (GPE) class? Second, what was the engagement of this student with a disability in a GPE class as compared to a randomly selected classmate without a disability? The research method was a case study involving systematic observation of 6 videotaped class sessions of a developmental volleyball unit in this student's GPE class. Social interactions of the student with a disability, as well as a randomly selected classmate without a disability, were examined using categories that have been validated in the research literature. Categories included with whom the child interacted (e.g., classmate, teacher), types of interactions (e.g., assistive interaction, complementary interaction, parallel interaction, dispute interaction), and interaction styles (e.g., verbal contact, physical contact) (Grenot-Scheyer, 1994; Strain, 1984). The ALT-PE coding system developed by Siedentop, Tousignant, and Parker (1982) was used to analyze student engagement time. Results regarding social interactions revealed that the student with a disability interacted with an assigned peer tutor to a greater degree than with his classmates (M = 568 secs compared to 156 secs). The student also had minimal interaction with his GPE teacher (M = 37 secs). Types of interactions were mostly as a member of a group (M = 47% of total interactions) and assistive interaction (M = 56% of total interactions). Interaction style was mostly verbal contact (M = 75% of total interactions) and eye contact (M = 78% of total interactions). Analysis of ALT-PE data revealed that the student with a disability was engaged in motor activity 42% of the observed intervals. The percentage engagement of his classmates ranged from 45 to 52. It is important to note that part of the motor engaged time for the child with a disability included modified activities to meet his motor needs. Due to the support of the peer tutor, the student with a disability did not have higher waiting time than students without disabilities. Findings suggest that the child with a disability was not isolated from his classmates and had numerous opportunities for social exchanges and skill practice (modified to his unique needs) in a GPE class with only the support of a classmate serving as a peer tutor.

Effects of a Top-Down Program on Teaching Young Adults With Intellectual Disabilities Volleyball Skills

Jiabei Zhang, Western Michigan University, and Leon L. Chen, Central Michigan University

The top-down approach places emphasis on teaching target skills selected from the top level of motor skill developmental sequence. This approach is believed to be one of the useful strategies for teaching individuals with disabilities. However, few investigations have been found to examine the effects of this approach in adapted physical education. The purpose of this investigation was to evaluate the effects of a top-down program on teaching young adults with intellectual disabilities volleyball skills. A pretest-posttest two-group experimental design was employed.

Participants were 20 young adults with mild intellectual disabilities, 11 females and 9 males, ages ranging from 17 to 25 years. Participants in the experimental group (5 females, 4 males; M age = 20.78) were taught volleyball skills using a top-down program, in which 3 task-analyzed skills (serve, pass, and set) were taught with two 60-min training sessions per week for 10 weeks. Those participants in the control group (6 females, 5 males; M age = 21.36) were involved in physical activities using low-body parts only without any volleyball skill training. Each participant in both groups was tested based on the task analysis of each skill in the first session (pretest) and the last session (posttest). A 2 (group) x 2 (test) analysis of repeated measures design involving multiple dependent variables (serve, pass, and set) was used to analyze the overall difference between groups over tests on dependent variables. Follow-up univariate tests, 2 (group) x 2 (test) analyses of repeated measures designs involving a single dependent variable, were computed after a significant difference was found in the overall test. Results of the overall test revealed a significant difference between groups over tests on dependent variables, LRATLO(3, 16) = 25.28, $p < .01$, Eta2 = .83, noting that both groups differed in their performance over tests on at least 1 of the dependent variables. Results of the follow-up tests noted significant differences between groups over tests on serve ($F[1, 18] = 32.02$, $p < .01$, Eta2 = .64), pass ($F[1, 18] = 13.29$, $p < .01$, Eta2 = .43), and set ($F[1, 18] = 39.65$, $p < .01$, Eta2 = .69), indicating that groups change at different rates over tests on skills. Specifically, the experimental group increased performance significantly, while the control group did not have any significant changes. These results indicated that the top-down program used in this investigation was effective in teaching individuals with mild intellectual disabilities 3 volleyball skills.

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Analysis on the Overhand Float Serving Motion in Female College Students

T. Endo and R. Mukawa

The purpose of this study was to investigate the overhand float serving motion on the skill level using an observational evaluation method and biomechanical analysis. Subjects of this investigation were 87 female college students. Fifteen key categories were selected for evaluating the serving motion. Subjects were filmed by VTR (shutter speed: 1/500 s) the process of taking a serve skill test. The main results obtained were as follows: (1) the overhand float serving motion of female college students was classified into 6 typical patterns. (2) Overhand float serving pattern that was classified by observational evaluation method had related to the serving skill accuracy. (3) Typical overhand float service patterns that were classified by observational evaluation method were analyzed biomechanically using stick pictures. There were remarkable differences between inexperienced serving patterns and experienced ones relative to the use of upper body twist.

An Investigation on the Theory of Spike – About Foreswing Phase

T. Miyakozawa and M. Tsukamoto

The purpose of this study was to investigate the theory of the spike, especially the foreswing. Results were as follows: (1) The back swing should be completed by the complex actions of arch and twisted body. (2) The contact point of spike should be basically created on the horizontal axis upward and in front of player's forehead. (3) There are 4 types of foreswings and each of them basically swings the arm. (4) To have an ideal swing that is able to make the highest hit point, the shoulder should be set closest to the head and the elbow should be passed through the highest point.

Shoulder Injuries and Care Among High School Volleyball Players

S. Tanaka, S. Tochibori, H. Shimojo and Y. Miyanaga

It is important to prevent chronic sports injuries. The coaches have a big influence on the young athletes for care of the injuries. We have surveyed shoulder injuries in high school volleyball players and prevention of the injuries for players who were registered for the 19th all-Japan high school volleyball championship tournament. One thousand two hundred seventy-two players (636 boys and girls each) and 160 coaches (103 males and 3 females) were investigated by a questionnaire, which was collected from approximately 70% of the players and 67% of the coaches. Shoulder pain was found among 218 players (about 25% of the players). The incidence of the shoulder pain was almost the same for boys and girls. Stretching and massage and icing were done to care for the shoulder pain for the players. Most of the coaches have advised their players to care for themselves. However, several players have felt anxiety about the fact that they do not know how to care for the injury. This study has demonstrated that it is essential to prevent the injuries for the young athletes that both players and coaches need to acquire knowledge about prevention of the injuries and how to deal with the injuries. We would like to suggest the following: (1) Both players and coaches master the knowledge of sports medicine. (2) We stress the importance of the emergency measures. (3) The players take care of themselves. (4) We collect talented people who have the knowledge of prevention of the injuries, rehabilitation, and the mechanism of the injuries.

A Study of the Libero System in High School Volleyball: An Investigation of Coaches of High School Volleyball Teams in Shizuoka

M. Kawai and G. Yamada

The Libero system was adopted in volleyball games this year. The purpose of this study was to investigate an availability of the Libero system. The results of reply of coaches of 115 high school teams in Shizuoka prefecture are summarized as follows: (1) More than 70% of the coaches admitted to the availability of the Libero system in volleyball games. (2) Upper-level teams were using the Libero system effectively more than lower-level teams. (3) The Libero system was effective to use short players in both upper- and lower-level teams. (4) The Libero system had a factor to entertain volleyball games; however, on the other hand, it had a problem to be placed at a disadvantage for lower-level teams.

Match Analysis Based on Rotation Phases in International Women's Volleyball Games – 1997 World Grand Champions Cup, Cuban Team's Analysis

D. Shimazu, K. Izumikawa, S. Yamamoto, H. Tanaka, M. Akashi, M. Sakai, T. Tahara and S. Harada

We analyzed the Cuban women's team. The team's match analysis was based on rotation phases during the 1997 international women's World Champions Cup. The Cuban team achieved a point rate of 32.88% and sideout success rate of 54.50%. Both rates were higher than those of the Brazilian, Chinese, Japanese, and Korean teams. When compared with the Russian team, the point rate was lower, but the sideout success rate was almost equal. In terms of the technical evaluation of the team rotations, the Cuban team showed the highest point rate (41.9%) when played in R4, and the highest sideout success rate (61.9%) when played in R2. The most contributive players in the respective attack formations were the attacker No. 8 and blocker No. 14 in the case of R4, and the attacker No. 8 and blocker No. 18 in the case of R2. The most outstanding individual performer in terms of the contributive rate of points and sideout successes was player No. 14 (point – 22.7%; sideout success – 21.1%). In the six-group comparison, player No. 14 in the blocker group showed the highest point rate (35.44%) when she was in the forward row (R3-R4-R5), and player No. 10 in the setter group showed the highest sideout success rate (57.45%) when she was in the forward row (R1-R2-R3).

The Study on the Physical Fitness of the Volleyball Player – The Cross-Sectional Analysis During 36 Years in all Japan Men's Team

(No English abstract was available)

Y. Kayamori, I. Miyauti and T. Okamoto

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Introduction of Volleyball-Style Game in the Courses of Study for Elementary School Education

S. Tochibori

Due to the recent amendments of the courses of study for elementary school, soft volleyball, along with softball, is added to constitute a part of the ball game exercises. Volleyball became a teaching material for the first time when the amendments of Physical Exercises Teaching Guidelines adopted volleyball as one of 12 ball games on May 27, 1926. This paper is to describe the process and to search remaining problems of the introduction of the volleyball-style game into the guidelines in Japan for the first time after World War II.

The Estimation of Tactical Classification of DIG and Approach to the Analysis of the Game

H. Goto

The purposes of this study were to attempt classification of DIG according to the theory of tactical classification and to approach the volleyball game's analysis, compared with classification of pass and receive in the past. The samples were 15 games for women of Tokai Intercollegiate Volleyball League in 1996. The results were summarized as follows: (1) in the all DIG (3,885), the cases of pass were 284 (7.3%), controlled dig were 1,469 (27.68%), dig were 1,488 (38.3%) and saves were 644 (16.6%). (2) The result of estimation of DIG suggested to clarified classification of DIG (pass>usual pass>control dig>usual receive and dig>saving: $p<.001$). (3) In the success rate of DIG, the cases of pass were 4.73 +/- 0.72, controlled dig 4.30 +/-0.83, dig 3.51 +/- 1.19, and saving 3.76 +/-1.17. (4) The acquisition rate of rally was 13.4% in pass, 53.6% controlled dig, and 30.6% dig.

The Prediction of Victory or Defeat in a Volleyball Game – Won Women's College Volleyball Team

T. Yonezawa, Y. Matumoto and H. Tawara

The purpose of this study was to predict victory or defeat in the volleyball game from the difference in scores between the teams. We observed 28 games, 92 sets of the 1999 Spring League matches among 8 intercollegiate women's volleyball teams in Zenkyusyu. Each set of a game was divided into the early stage (from 0 points to 8 points), the middle stage (from 10 points to 16 points), and the end stage (from 18 points to 22 points). The difference in scores between the teams was calculated for each stage of a set. And the regression coefficient between the score differences and the percentages of winning the set was calculated. The major results of this study were as follows: (1) It was possible to predict winning a set or not from the score difference between the teams because there was a significant correlation between the score and the winning rate. (2) The winning rate became more than 70% when the team led the opposing team by 3 points in the early stage. Then the winning rate became 0% when the team was 6 points or more behind the opponent team. (3) The winning rate became more than 90% when the team led the opposing team by 4 points in the middle stage. Then the winning rate became 0% when the team was 6 points or more behind the opposing team. (4) The winning rate became 90% or more when the team led the opponent team by 2 points in the end stage.

Match Analysis Based on Rotation Phases in International Men's Volleyball Game – 14th World Volleyball Men's Championships Final, 1998 – Italy and Yugoslavia

D. Shimazu, K. Izumikawa, S. Yamamoto, M. Akashi, M. Sakai, T. Tahara and S. Harada

A game analysis was made of the Italy vs. Yugoslavia match in the 14th Men's World Volleyball Championships in November 1998. Through the analysis, it was found that there was a positive or negative significant correlation, at the level of 0.1% or 1%, in the subject match (by in-court serve), between the net score (Michael R. Hebert system) and the point rate of 1 team, and the net score and point rate of the other team, and between the net score and the sideout success rate of 1 team, and the net score and sideout success rate of the other team. No great difference was observed in terms of the above-stated correlation between the 2 teams. This means that the correlation will be utilized in the author's analysis and research activities in the future. But there was no significant correlation in the subject match (by all court serve, 2 items), and set a task to ours. We analyzed that point rate and sideout success rate in 1 or several rotation phases, points and sideout successes in front-row or back-row, contributive rate of individual player's points or sideout successes, back spike rate of individual player's points or sideout successes, determinative positions or individual player's spike or block. Based on the above findings, characteristics of the remaining rotation phases were grasped. The author believes that this analysis can be used to analyze games of volleyball matches.

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The Study on the Evaluation of Attack Performance in a Volleyball Game: The Analysis of the Attack Performance on the Construction Type of Attack

K. Kudo and Y. Kayamori

Attack performance in volleyball was not evaluated only with the result of the end situation of attacking, but this research aimed at grasping the attack performance of the team, including the ability of attack construction conditions until it reached there objectively. The samples were 28 games, 106 sets for women of Kansai intercollegiate volleyball league in 1999. Following were the results: (1) There was a difference in appearance frequency of the 4-attack situation in the volleyball game. And the importance of attacking from the serve reception and attacking from attack reception was admitted to be in the usual report. (2) A correlation was not recognized between the attack efficiency and the final order of the league. As for the attack efficiency, it became clear that the attack performance of the team was not shown precisely. Moreover, a correlation is recognized between miss attacking rate and the final order of the league, and it is necessary to add an attack mistake to the object of the evaluation. (3) When attack performance in volleyball was evaluated, it was recognized that we should calculate attack efficiency with the one by the attack situation, the attack construction type separately. (4) As for the applicable group of this research, the validity of the way that an attack construction type evaluates an attack performance separately was admitted, and the characteristics of the attack performance of the team could be grasped in detail.

A Study on the Setter in Volleyball Games

K. Minowa and T. Yoshida

NK Junior College Volleyball Team had 3 setters on starting lineup for the games in the 1993 Spring and Fall Kyushu League of Intercollegiate Women's Volleyball and West Japan Division of Intercollegiate Women's Volleyball Tournament. The purpose of this study was to extract the requirements for being a successful setter by comparing the performance of 3 setters and investigating to find in what situation the differences in setting abilities and setting tactics become clear. The main findings were as follows: (1) It was clarified that one of the requirements for being a successful setter was to be able to jump-set at the place away from the normal setting position. (2) It was clarified that the difference of the ability of setting tactics would not be clear in the attacking phase from the serve-receive that the setter can make a setting plan beforehand. But it would be clear in the attacking on transition, where the setter was required to keep up with changing situations. (3) It was clarified that the difference in setting abilities became evident when the setter ran the combination attack or did a third-tempo set from the place away from the normal setting position. (4) It was clarified that the difference of the result of setting would not be clear in the attacking phase from the serve-receive, but would be clear in the attacking on transition.

The Effectiveness of Using the Assisting Device in Underhand Pass Coaching in Volleyball

K. Kawada, S. Tochibori, Y. Fukuhara, T. Miyakozawa, Y. Nakanishi and I. Ishimaru

In this research, we have tested how effective our specially designed assisting device can be in coaching, making a comparison between skilled players and beginners. From the results, we can conclude that the device which we have designed is effective in underhand pass coaching in terms of the following: (1) By using the assisting device, beginners can receive the ball with a motion similar to that of skilled players in terms of the following: the arm angle before the ball is received can be extended; the arm angle and the bending forward angle when the ball is received can be extended; the swinging motion of the arms, which is defined in terms of the arm angle and the tilt angle, can be reduced. (2) By using the assisting device, female players can perform the forward motion more easily. (3) By using the assisting device, beginners can receive the ball more successfully. (4) Skilled players can gain the good image of the receiving motion during practice. (5) Although beginners equipped with the device may have some difficulty moving around, it is not so heavy as to cause too much discomfort. They find it easier to receive the ball immediately after the device is removed, which shows that its effectiveness can be clearly perceived. Some points that need to be taken into consideration have become clearer as we have continued our experiment and coaching. With regard to the arm angle in particular, when receiving a serve, it should be set at approximately 75 degrees for men and 65 degrees for women.

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Biomechanical Analysis of the Torso Twisting During the Spiking Motion in Volleyball

T. Wada, M. Ae, T. Endo and M. Tanaka

The purpose of this study was to investigate the torso twisting during the spiking motion of Japanese elite male volleyball players. The spiking motion of volleyball players was videotaped by 2 high-speed VTR cameras operating at 250 Hz to obtain 3-dimensional coordinates data of the body segments and the center of the ball. The velocity of the ball, hand and shoulder and twisting angle of the torso were calculated. The results were summarized as follows: (1) The large twisting angle and the large angular velocity of the torso twisting contributed to increase the hand velocity at the impact. (2) Maintaining the shoulder velocity in the direction of the swing at the impact helped to achieve large ball velocity. (3) To obtain large shoulder velocity in the direction of swing at the impact, they used 2 types of torso motion: the first type predominated forward flexion of the torso; the second one predominated forward twisting of the torso. Although most of the players combined both of the torso motions during spiking motion, the twisting type is preferable to obtain large shoulder velocity and then ball velocity as a result.

The Study of Management of the Volleyball Supervisory Or-ganization in France – Focused on FFVB

Y. Matsuda, T. Miyakozawa and Y. Nakanishi

In a leading study, it has been made clear that JVA must develop the management in conformity with an idea of "for all." Then in this study, we focused on France, which in recent years, the international sports performance is better and better, and sports administration fills up. Following is the process of this study. First, we made clear the "obtained good results" to be able to be proven as the numerical value. Next, we made clear the actual condition in the organization and enterprise of background of the "obtained good results." Further, we worked out the idea and consciousness structure on which such a organization system is based on. Then, by these results, we analyzed and considered the characteristics in FFVB organizational structure from both viewpoints of coaching, namely performance progress and spread progress and of administration, namely the "organization in organization" structure. Finally, we suggested the direction to assignments solution in JVA management. By this, we could do this study as an introduction to the next step study, as to say, to extract concrete ideas for assignment solutions by making clear "volleyball identity in Japan" from a comparative study with the exterior.

The Study on the Evaluation of Attack Performance in Volleyball – 2000 Olympic Final Qualifications: The Attack Performance Comparison of the Japanese Team and the Opposing Team

K. Kudo, D. Simazu, K. Izumikawa, T. Tahara and Y. Kayamori

The purpose of this research explains the characteristics of the attack in the Japanese team and the opposing team by evaluating the player's attack performance in the one by the attack situation, the one by the attack construction type, and it is to investigate the strengthening point of the future Japanese team. The samples were 3 matches. Eleven sets in the 2000 Olympic Finals qualifications for women's volleyball. Followihg are the results: (1) Though the appearance frequency of T3-3 in SRA showed a tendency of being high, attack performance of the Japanese team was low, and lack of scoring ability of the attacker was remarkable. (2) The appearance rate of the quick attack of the center player in SRA of the Japanese team is low, and guesses that an attack pattern becomes monotonous to be the cause of the lowness of attack performance. (3) Lack of scoring ability of side attacker with T1-3 in ARA and T1-2 is remarkable, and you must raise the decision power of the deep set in the Japanese team. (4) The establishment of the combination which can show high attack performance with improving each player's attack performance in the whole of the team, and the attack system is necessary for the Japanese team.

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A Basic Study for Providing Instructional Materials of Volleyball Based on Game Structure

O. Suzuki

Although volleyball is one of several types of ball games, the essential component in all such games is a competition leading to a future unknown result. Distinguishing the structure of volleyball based on the objective of competition, the competitive task, and the method selected for such task solving, this study argues a new theory to utilize volleyball as instructional material. In all cases including volleyball, the objective of the active competition phase consists of engaging in one of the following enterprises: ball progressing (or multiple ball progressing in the case of golf or bowling) to an objective point or individual player movement to an objective point. Ball and player progressing is accomplished through offensive or defensive group or individual activity. Considering these elements, volleyball can be classified into "breakthrough games." Furthermore, based on the layered structure of defensive interface and the selected method of ball progressing corresponding to that structure, breakthrough games including volleyball were further divided into subcategories. Those findings illustrated a model for physical education teachers attempting to provide instructional materials for volleyball.

A Study on the Psychological Aptitude of Volleyball Players Compared to Other Sport Players With Meta Analysis

T. Endo and T. Kado

The purpose of this study was to clarify the psychological aptitude of the volleyball players in terms of athletic motivation by using meta analysis compared to other sport players. Fifty-one papers were found from search for published scientific reports that used TSMI (Taikyo Sport Motivation Inventory), a testing measure to evaluate athletic motivation; 28 of those papers contained data needed for meta analysis (elite non-volleyball players' mean scores, standard deviations and number of subjects) on which we conducted the analysis. One thousand three hundred seventy-seven elite volleyball players' data were also used for paralleling with elite non-volleyball players. Meta analysis of all subjects revealed that the effect sizes for 6 of TWMI subscales (TS6; Tension Anxiety, TS11: Fighting Spirit, TS13: Looseness, TS15: Value of Athletics, TS:16 Planning, TS:17 Attribution to Effort) were in the range between 0.20 and 0.49 and those for the remaining 11 sub scales were between 0.00 and 0.19. As a result, it was suggested that although the difference was slight between volleyball players and non volleyball players in terms of athletic motivation, there were some important differences in factors of psychological aptitude for the elite volleyball players.

A Development Study on Scouting Program by Use of Cinematography - An Analysis of Serve Reception in Volleyball

Y. Hashihara and K. Hama

This study was designed to prepare the scouting program by use of the cinematography, and to analyze the skill of serve reception during the volleyball games. The cinematographic image taken by the video camera during the game was reflected on the screen of a notebook computer. After digitizing the middle point of the player's feet, the position of serve receiving formation and the location passed actually were calculated by Two-Dimensional Director Linear Transformation Method. The performance of serve reception was evaluated into 3 grades, where a pass that can be set into combination play was +1; a pass that can be set to either end spiker was 0; an ace or pass that cannot play attacking was -1. The analysis was expressed graphically on the screen so that the coach could supplement important strategy in a brief time-out period. The scouting program has been tested and validated as the videotape recorded the match was played back.

Study on Data Input on Touch Volleyball

T. Shigenaga, N. Ezaki and C. Miyaji

We have developed it as a tactical support system for volleyball by using 2 laptop personal computers connected by wireless LAN. Each computer can implement by using a touch sensor function on display. The developed system consists of 3 functions: Data input, tactical support and data analysis. In this paper, we describe data input function. The input item on data input function is as follows: "Touch volleyball."

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Contact: darlene.kluka@usav.org for additional information.