BRIEF REVIEW

PHYSICAL AND PHYSIOLOGICAL ATTRIBUTES OF FEMALE VOLLEYBALL PLAYERS—A REVIEW

RONNIE LIDOR[1,2] AND GAL ZIV[1]

[1]The Zinman College of Physical Education and Sport Sciences, Wingate Institute, Israel; and [2]Department of Learning, Teaching, and Instruction, Faculty of Education, University of Haifa, Haifa, Israel

ABSTRACT

Lidor, R and Ziv, G. Physical and physiological attributes of female volleyball players–a review. *J Strength Cond Res* 24(7): 1963–1973, 2010–The main objective of this article was to review a series of studies ($n = 31$) on physical attributes, physiological attributes, and on-court performances of female volleyball players. Empirical and practical knowledge emerging from studies on training-related issues in volleyball, such as body mass, fat-free mass, aerobic profile, strength, and agility and speed, should be integrated and applied when planning annual training programs for volleyball players. Based on our review, it was found that (a) players of a higher skill level are taller, somewhat heavier, and have higher vertical jump values than players of a lower level; (b) the aerobic profile of female volleyball players is similar to that of female basketball players; (c) ballistic resistance training can increase vertical jump values in female volleyball players; and (d) preseason conditioning should be conducted to prevent fatigue and reduced performance at the beginning of the season. Among the research concerns discussed in the article are that there is a lack data for on-court performance and time–motion analysis in female volleyball players and that more experimental/manipulative studies are needed to examine the effectiveness of different training programs on physiological attributes of female volleyball players. Two practical implications are suggested for volleyball and strength and conditioning coaches: (a) functional and nonfunctional overreaching should be carefully monitored when planning strength and conditioning programs, and (b) volleyball programs should include ballistic-type training.

KEY WORDS athletic performance, physical fitness, exercise test, testing protocols, training programs

---

Address correspondence to Dr. Ronnie Lidor, lidor@wincol.ac.il.

24(7)/1963–1973

Journal of Strength and Conditioning Research

INTRODUCTION

The development of performance-enhancement training programs for female volleyball players requires volleyball coaches, strength and conditioning coaches, and other professionals who work with the volleyball player (e.g., athletic trainers, physiotherapists, and physicians) to use empirical and practical knowledge from various sport-related domains, among them being exercise physiology and sports medicine. Relevant information on training-related issues, such as physical attributes (e.g., height, body mass, and fat-free mass), physiological attributes (e.g., aerobic profile, strength, vertical jump ability, and agility and speed), and on-court data (e.g., heart rate and blood lactate level), can be effectively implemented in volleyball programs, particularly in strength and conditioning programs specifically developed for the female volleyball player.

An attempt was made in this article to integrate knowledge on physical attributes, physiological attributes, and on-court performances of female volleyball players that can be applied by those involved in the short- and long-term planning processes of annual training programs. This integrated knowledge can be also beneficial when these professionals assess the contribution of their programs to the development of the female volleyball players. However, a careful approach should be adopted by those professionals who work with volleyball players in the implementation of knowledge gained from studies on female volleyball players. This is to say that the methodological limitations of these studies, and any measurement issues associated with the physical tests given to the players in these studies, should be taken into account.

The purpose of the current article is threefold: (a) to review a series of studies ($n = 31$) on physical attributes, physiological attributes, and on-court performances of female volleyball players, including professional players, national team players, and university intercollegiate players; (b) to discuss a number of methodological concerns and testing limitations associated with the reviewed studies; and (c) to provide practical recommendations for volleyball coaches and strength and conditioning coaches who work with female volleyball players.

The reviewed articles were selected from an extensive search of the English language literature, including major computerized databases (PubMed and SPORT Discus) and library holding searchers. Search terms included, among others, volleyball, volleyball physiology, and volleyball players. Articles on adolescent players and those articles combining data for female and male players were excluded. Thirty-one articles matching our criteria were included in our review.

PHYSICAL ATTRIBUTES

A summary of the physical attributes for the female volleyball players across the reviewed studies is presented in Table 1. The reviewed data reveal several noteworthy findings. Height and body mass values vary between 164.3 ± 4.0 cm (7) and 62.5 ± 8.0 kg (13) to 187 ± 5.4 cm (23) and 75.1 ± 7.4 kg (5), respectively. These variations in the data can be because of a number of factors, such as the genetic profile of the players, their level of play, and the selection process they underwent.

Physical characteristics can differentiate among players of different levels. Although 1 study (9) indicated no differences in height and body mass between national and university level players, other studies showed that players of higher levels are taller and somewhat heavier than players playing at lower levels (3,12,21,32). In one study (21), the differences between players of different positions in divisions A1 and A2 in the Greek first national league were examined. Hitters, centers, and setters were significantly taller in division A1 (181.2 ± 4.5, 182.0 ± 4.6, and 176.9 ± 4.1 cm, respectively) compared to division A2 (173.4 ± 6.2, 178.7 ± 4.9, and 170.9 ± 4.2 cm, respectively). No differences in body mass were found between players of the 2 divisions. Differences in percent body fat were found only in opposites (A1: 20.5 ± 3.0% vs. A2: 25.7 ± 3.4%). In this study (21), the physical characteristics between players playing various positions were also compared, and it was found that liberos appear to be smaller than players in other positions (except for setters). In addition, centers and opposites were taller compared to hitters, liberos, and setters.

Three studies examined changes in physical characteristics over time (10,13,17). No changes in body mass, percent fat, and fat-free mass were observed after a supervised off-season strength and conditioning program of NCAA division I players (10). In another study (17), percent fat of NCAA Division I players increased and fat-free mass decreased at the end of the competition phase of the season compared to baseline values, whereas body mass remained stable. In contrast, another study (13) revealed slight decreases in percent fat throughout the entire season. Although an increase in percent fat can hinder performance, it should be noted that the changes indicated in all studies were small and could have been affected, at least in part, by the accuracy of the type of instruments used and the measuring methods. In addition, even if the data reflect actual changes in body composition, this does not necessarily mean that these changes influenced performance. Body composition can vary over time, as Johnson et al. (17) suggested, and therefore, a range of values rather than one strict value should be set for each individual player.

Comparing volleyball players to players of other team sports and to nonathletes can shed light on the physical attributes that are unique to those players. In one study (25), intercollegiate volleyball players were significantly taller and had higher body mass and fat-free mass compared to nonathletes. Compared to intercollegiate basketball players, the volleyball players had shorter arms but shared similar height and body mass. In another study (4), physical attributes of basketball, handball, and volleyball players playing in division 1 in Greece were compared. It was found that volleyball players were taller (177.1 ± 6.5 cm) than both basketball (174.7 ± 7.8) and handball (165.9 ± 6.3) players. The volleyball players were also heavier (69.5 ± 7.4 kg), had a higher fat-free mass (53.2 ± 5.3 kg), and lower percent fat (23.4 ± 2.8%) than the handball players (65.1 ± 9.1 kg, 48 ± 6 kg, 25.9 ± 3.3%, respectively). It is evident from these data and the data on volleyball players of different proficiency levels that being tall is advantageous in volleyball.

Probably the most important aspect of describing physical characteristics is in determining whether or not they are related to success. A recent review on physical attributes, physiological characteristics, on-court performances, and nutritional strategies of female and male basketball players (36) suggested that tallness and longer arm span were associated with the top team players but not bottom team players in one tournament. However, this observation was based on findings from 2 studies only. Similarly, we found only 3 studies examining the relationship between physical characteristics and performance (8,11,26).

In one study (26), fat content was a significant discriminant between players of the most successful (12.2 ± 2.8 kg) and the least successful (15.0 ± 5.4 kg) teams in a 1977 invitational volleyball tournament. In another study (11), height was found to be significantly correlated with the final standings in a 1974 US National Championship Tournament. Lastly, no correlations were found between anthropometric variables and spiking velocity in NCAA division I players (8).

Although body fat and height are assumed to affect volleyball playing performance, and although data from 2 correlative studies corroborate this assumption, scientific evidence for this notion is still lacking. More studies are needed to assess the contribution of physical attributes to actual performance. Success in sports is affected by a number of variables in addition to the notably important one of physical attributes, among them being the physiological attributes of the players and their psychological state.

PHYSIOLOGICAL ATTRIBUTES

The aerobic profile, strength, vertical jump ability, and agility and speed of female volleyball players are discussed.

Table 1. A summary of the physical attributes of female volleyball players.*†

Study	Subjects	Height (cm)	Mass (kg)	%BF	FFM (kg)
Alfredson et al. (1)	First division players practicing 8 h wk^{-1} ($n = 11$)	173.4 ± 6.3	68.8 ± 7.0	NA	NA
Amasay (2)	NCAA division II players ($n = 10$)	178.0 ± 6.0	70.9 ± 9.9	NA	NA
Barnes et al. (3)	NCAA division I ($n = 9$), division II ($n = 11$), and division III ($n = 9$) players	Division I: 177.9 ± 6.3 Division II: 174.3 ± 7.7	Division I: 73.3 ± 7.7 Division II: 71.5 ± 9.8	NA	NA
Division III: 171.0 + 8.0	Division III: 69.8 ± 6.9				
Bayios et al. (4)	First national league players	177.1 ± 6.5	69.5 ± 7.4	23.4 ± 2.8	53.2 ± 5.3
Cardinale and Lim (5)	Professional players competing at a high level ($n = 16$)	183.4 ± 8.4	75.1 ± 7.4	NA	NA
Coutts (6)	Canadian National Women's volleyball team ($n = 11$)	178.1 ± 5.4	70.8 ± 6.5	NA	NA
Fardy et al. (7)	Case Western Reserve Univ. intercollegiate starting players ($n = 6$)	164.3 ± 4.0	65.2 ± 12.1	NA	NA
Ferris et al. (8)	NCAA division I players ($n = 13$)	176.7 ± 4.6	69.7 ± 10.8	22.2 ± 5.0	15.8 ± 5.6
Fleck et al. (9)	Players of US Women's National Volleyball team of 1980 ($n = 13$) and of US Women's University Games volleyball team ($n = 13$)	National team: 179.3 ± 7.7 University team: 178.9 ± 4.7	National team: 68.5 ± 7.6 University team: 71.6 ± 5.0	National team: 11.7 ± 3.7 University team: 18.3 ± 3.4	National team: 60.3 ± 6.1‡ University team: 58.4 ± 3.9‡
Fry et al. (10)	NCAA division I players ($n = 14$)	Starters: 170.4 ± 8.1 Nonstarters: 173.2 ± 5.2	Starters: 64.1 ± 9.5 Nonstarters: 64.4 ± 4.6	Starters: 18.7 ± 3.0 Nonstarters: 20.2 ± 2.1	Starters: 52.1 ± 7.7 Nonstarters: 51.4 ± 3.4
Gladden and Colacino (11)	Players at US Volleyball Association's national championship 1974 ($n = 88$)	172.2 ± 6.0	65.8 ± 6.0	NA	NA
Gualdi-Russo and Zaccagni (12)	Italian A1 ($n = 129$) and A2 ($n = 115$) league players	A1 league: 178.4 ± 5.8 A2 league: 176.7 ± 4.9	A1 league: 71.2 ± 7.0 A2 league: 70.9 ± 6.9	NA	NA
Häkkinen (13)	Players from 2 teams–exp. group ($n = 9$), con. group ($n = 8$)–playing in the official leagues in Finland. Exp. group performed more conditioning sessions during the season	NA	Exp: preseason: 66.7 ± 5.6, postseason: 67.3 ± 6.8 Con: preseason: 63.1 ± 7.0, postseason: 62.5 ± 8.0	Exp: preseason: 25.3 ± 2.8, postseason: 24.9 ± 3.1 Con: preseason: 25.1 ± 1.9, postseason: 24.3 ± 1.6	Exp: preseason: 49.8 ± NA§,Postseason: 50.5 ± NA§ Con: preseason: 47.3 ± NA§,postseason: 47.3 ± NA§
Hosler et al. (16)	Players from the teams competing in the 1977 University of Houston invitational tournament	169.9 ± 6.1	65.1 ± 7.8	21.5 ± 3.5	51.1 ± NA§

(Continued on next page)

Johnson et al. (17)	NCAA division I players measured pre and postseason ($n = 14$)	175.2 ± 3.6	Pre: 67.7 ± 2.0 Post: 67.7 ± 1.7	Pre: 19.4 ± 1.1 Post: 20.9 ± 0.8	Pre: 54.5 ± 1.3 Post: 53.4 ± 1.0
Kraemer et al. (18)	Members of Penn State varsity team ($n = 18$)	172.7 ± 8.6	68.7 ± 8.1	NA	NA
Lawson et al. (20)	Recreationally competitive players playing at least once a week ($n = 12$)	169.4 ± 5.4	66.0 ± 7.9	NA	NA
Malousaris et al. (21)	Greek first national league divisions A1 ($n = 79$) and A2 ($n = 84$)	Division A1: 179.6 ± 5.8 Division A2: 174.7 ± 6.2	Division A1: 71.0 ± 8.2 Division A2: 68.2 ± 6.3	Division A1: 22.7 ± 2.9 Division A2: 24.1 ± 2.6	Division A1: 54.8 ± 5.7 Division A2: 51.7 ± 4.5
Marey et al. (22)	Northeast Missouri State University ($n = 14$) and Graceland College ($n = 23$)	170.2 ± 5.3	64.3 ± 6.6	NA	NA
Marques et al. (23)	Professional players of national first division of Portugal and the European cup ($n = 10$)	187 ± 5.4	74.6 ± 8.1	NA	NA
Morrow et al. (26)	Players from the teams competing in the 1977 University of Houston invitational tournament	Most successful: 172.0 ± 6.1	Most successful: 64.2 ± NA§	Most successful: 19.0 ± NA§	Most successful: 52.1 ± 4.4†
	Most successful teams ($n = 34$) and least successful teams ($n = 38$)	Least successful: 167.5 ± 5.8	Least successful: 65.5 ± NA§	Least successful: 23.0 ± NA§	Least successful: 50.4 ± 5.6‡
Morrow et al. (25)	Intercollegiate players ($n = 110$)	170.4 ± 6.3	65.1 ± NA §	20.4 ± NA§	51.8 ± 5.2‡
Nesser and Demchak (27)	NCAA division I players in 2004-5 season ($n = 3$) and 2005-6 season ($n = 11$)	2004–2005: 177.9 ± 5.6 2005–2006: 175.5 ± 8.0	2004–2005: 70.2 ± 3.8 2005–2006: 67.4 ± 7.5	NA	NA
Newton et al. (28)	NCAA division I players ($n = 14$)	180.2 ± 7.3	70.5 ± 6.2	NA	NA
Smith et al. (31)	Exp. group: University of Calgary Women's Intervarsity Volleyball team. ($n = 10$) Control group: members of a club team involved in practice only ($n = 5$)	Exp: 174.7 ± 1.8‖ Control 168.4 ± 1.8‖	Exp: 66.7 ± 2.1‖ Control 61.9 ± 2.1‖	NA	NA
Spence et al. (32)	1975 US Women's volleyball training team elite players ($n = 15$)	Pan-American: 183.7 ± 8.3 Non–Pan-American: 178.9 ± 5.8	Pan-American: 73.4 ± 6.1 Non–Pan-American: 63.0 ± 3.1	NA	NA
Stech and Smulsky (33)	High performance players with ~8 years of experience ($n = 10$)	181.9 ± 8.4	72.8 ± 10.8	NA	NA
Wnorowski (35)	Top Polish players from 2005 season ($n = 12$)	182.2 ± 5.1	73.8 ± 7.8	NA	NA

*Data shown as mean ± *SD*.
†BF = body fat; FFM = fat-free mass.
‡Lean body weight in original paper.
§Data not available in original paper, calculated by authors.
‖Values are standard error of measurement.

Aerobic Profile

Although volleyball is a game of an intermittent nature, a high aerobic capacity is still important, especially in multiset games where maintaining a high level of performance over time is required. In one study (32) of 15 members of the 1975 US women's volleyball training team, $\dot{V}O_2$max values as obtained from a maximal incremental treadmill test were 41.7 ± 3.6 $mlO_2 \cdot kg^{-1} \cdot min^{-1}$ for the Pan-American team and 44.2 ± 8.5 $mlO_2 \cdot kg^{-1} \cdot min^{-1}$ for the non–Pan-American team. In another study (9) reporting on 13 members of the 1980 US women's national team and 13 members of the 1979 US women's university games team, $\dot{V}O_2$max values of 48.8 ± 5.1 and 49.9 ± 5.3 $mlO_2 \cdot kg^{-1} \cdot min^{-1}$, respectively, were obtained during a maximal incremental treadmill testing. In both of these studies, only descriptive statistics were provided, and hence, it is unclear whether or not the differences between groups were significant.

Two studies examined changes in $\dot{V}O_2$max throughout the competition phase of the season. In 1 study (7) of 6 starting players of the 1974 Case Western Reserve University intercollegiate volleyball team, postseason $\dot{V}O_2$max values (33.0 ± 2.6 $mlO_2 \cdot kg^{-1} \cdot min^{-1}$) were significantly higher than those obtained in preseason (28.2 ± 1.5 $mlO_2 \cdot kg^{-1} \cdot min^{-1}$). These values were obtained from a submaximal cycle ergometer test. Another study (13) examined players from 2 volleyball teams of the official league in Finland. The experimental team had 3–4 conditioning sessions in the preseason (one of which was dedicated to endurance training), and 2–3 conditioning sessions during the season (none of which concentrated on endurance training). The control team participated in only 1–2 conditioning sessions throughout the season. $\dot{V}O_2$max values were obtained from an incremental cycle ergometer test and did not change significantly in the experimental team (pre: 47.3 ± 1.7, post: 48.1 ± 3.4 $mlO_2 \cdot kg^{-1} \cdot min^{-1}$) or in the control team (pre: 48.2 ± 2.7, post: 45.0 ± 5.9 $mlO_2 \cdot kg^{-1} \cdot min^{-1}$). The authors of this study suggested that the weekly practices and the games played during the season were sufficient in maintaining the initial aerobic capacity.

Lastly, one study (10) examined the effects of an off-season 12-week supervised strength and conditioning training program on NCAA division I players. The endurance portion of the program included 4 30-minute weekly sessions at 80% maximal heart rate. Endurance capacity was assessed from a maximal effort 2-mile run. Initial values revealed no differences in running time between starters and nonstarters (999.2 ± 44.3 vs. 964.4 ± 88.9 seconds, respectively). Two-mile running time combined for both starters and nonstarters ($n = 10$) improved significantly from baseline values (966.6 ± 56.5 seconds) to the end of the 12-week program (946.2 ± 58.2 seconds). It was suggested that these running times were reflective of estimated $\dot{V}O_2$max values of about 45 $mlO_2 \cdot kg^{-1} \cdot min^{-1}$. Subsequent to this supervised program, 7 players were assessed after another 12 weeks of unsupervised conditioning. No changes in 2-mile running times were indicated after the additional 12 weeks.

The $\dot{V}O_2$max values of volleyball players are similar to those reported for basketball players (~44.0–54.0 $mlO_2 \cdot kg^{-1} \cdot min^{-1}$) (36). The only exception is the unusually low values reported by Fardy et al. (7). These low values can be explained, at least in part, by the low level of the players and by the testing methodology, namely, a submaximal cycle ergometer test.

Strength

Muscle strength is an integral part of sports performance. There are several methods for assessing muscle strength, and different studies use different methodologies. Hence, it is difficult to compare results among studies.

Three studies reported isokinetic bench press and leg press values at $20° \cdot s^{-1}$ (16,25,26). Two studies used the same pool of players from the 1977 University of Houston Invitational Volleyball Tournament. One study (16) reported values of 40.7 and 144.5 kg for the bench press and leg press, respectively (values presented in lbs in the original paper). In the second study (26), values were reported for players of the most successful vs. the least successful teams in the tournament. Bench press and leg press values were 46.45 ± 11.04 and 155.42 ± 27.39 kg, respectively, for the players of the most successful teams, and 37.57 ± 9.53 and 137.91 ± 28.96 kg, respectively, for players of the least successful teams. A comparison of volleyball players, basketball players, and nonplayers revealed that basketball players (bench press: 44.37 ± 10.97 kg, leg press: 179.65 ± 35.48 kg) were stronger than volleyball players (bench press: 40.59 ± 9.81 kg, leg press: 141.42 ± 27.09 kg), and both volleyball and basketball players were stronger than nonplayers (bench press: 30.59 ± 8.14 kg, leg press: 128.45 ± 29.68 kg) (25).

Isokinetic testing was also conducted in a study comparing concentric and eccentric shoulder and elbow strength in female volleyball players and nonactive women (1). Shoulder and elbow strength are important for spiking and serving. As expected, the volleyball players had significantly higher concentric and eccentric peak torque of the shoulder and elbow rotator muscles but not for concentric flexion peak torque in the elbow. The authors of this study suggested that the obtained results could be explained by the fact that during spiking and serving the flexors of the elbow are used mainly to decelerate the arm after hitting the ball. In another study examining isokinetic strength (8), a significant correlation was found between arm extension torque at $270° \cdot s^{-1}$ and spiking velocity. Other isokinetic torque values (e.g., hand flexion, internal arm rotation, and forearm extension) did not correlate with those of spiking velocity. Although correlational in nature, these results suggest that high torque at high angular velocity may be important to volleyball players. This is to be expected, because high arm speeds are required for a volleyball spike (8).

We found 4 studies that examined the effectiveness of a resistance training program on strength parameters (10,13,23,31). In one study (10), the effects of a 12-week off-season training program were examined in NCAA division I players. The training program was composed of 4 resistance training sessions and 2 plyometric sessions each week. Baseline values showed that starters were, in general, stronger in concentric type exercises than nonstarters (e.g., 1 repetition maximum bench press: 45.7 ± 7.1 vs. 38.6 ± 3.8 kg, respectively). Starters remained stronger than nonstarters even after absolute values were divided by fat-free mass. However, no differences were found in isometric- and isokinetic-type exercises between starters and nonstarters. In addition, the 12-week program led to significant increases in isometric and concentric strength values (e.g., 1 repetition maximum [1RM] bench press; pre: 42.7 ± 6.9 vs. 46.8 ± 7.5 kg). Interestingly, the correlation between 1RM values and 1RM divided by fat-free mass was found to become lower as the season progressed. This may suggest that, at least in part, the increase in strength was because of neural mechanisms rather than a pure increase in muscle mass. Increases in dynamic strength were also observed during 12 weeks of an in-season resistance training program consisting of 250-minute weekly sessions (23). Significant increases were found in the 4RM bench press (pre: 40 ± 2.8 kg, post: 47 ± 3.5 kg) and the 4RM parallel squat (pre: 92 ± 11.1 kg, post: 104 ± 13.6 kg) after the 12-week program.

Another study (13) examined leg extension isometric force during the competition phase in 2 groups of players from the official volleyball league in Finland. The control group participated in 1–2 endurance and strength sessions each week and showed no improvement in force production. The experimental group participated in 3–4 conditioning sessions during the preseason (out of which 2–3 were for strength development) and 2–3 sessions during the competition phase of the season. The maximal rate of force development increased significantly over 4 months in the middle of the season. However, maximal force did not increase and was actually reduced by the end of the season. This reduction in maximal force occurred after a cessation of 5 weeks in the resistance training. It was explained in this study that the overall volume of endurance and volleyball drill training may have interfered with strength development. However, it is also likely that the testing methodology (i.e., isometric strength) failed to measure changes in dynamic strength. Indeed, the players did not participate in isometric training. It is possible that different strength testing protocols (e.g., concentric strength) would have resulted in increases in strength values. Lastly, a 6-week isokinetic resistance training program failed to increase upper-body strength as measured on an isokinetic machine, but increased knee extension values at a velocity of $180^\circ\cdot s^{-1}$ (31).

Vertical Jump

Vertical jump (VJ) is probably the most relevant power testing protocol for volleyball players, because it is a crucial skill in the game (e.g., in blocking and spiking). Comparing players of different skill levels can show the importance of VJ in volleyball. In one study (9), a 15% difference in a countermovement jump (CMJ) was observed in US female national team players, who jumped higher (52.4 ± 4.5 cm) than university games team players (45.5 ± 6.4 cm). Similar differences were observed between female Pan-American (52.5 ± 6.0 cm) and non–Pan-American players (47.3 ± 4.9 cm) (32) and between NCAA division I players (36.4 ± 2.5 cm) and division III players (30.2 ± 7.2 cm) (3). The differences in VJ values (~15 cm) between the 2 former studies and the latter study can be explained by the testing apparatus used–jump and mark a wall (9,32) vs. force plate measurement (3), and by the skill level of the players.

Vertical jump performance also appeared to be related to success in a national volleyball tournament. Standing reach, VJ, and absolute jump height were correlated with the final ranking of the teams ($r = 0.44$–0.63) during the 1974 US National Championship Tournament (11). The authors of this study suggested that a “critical height” above the net exists for optimal spiking and blocking and that the players who are able to reach this threshold have an advantage over those players who fail to reach it. However, a later study (22) did not find VJ performance to be a contributing factor discriminating between winning and losing teams. Similarly, no relationships between VJ and spiking velocity were found in a study of NCAA division I female players (8). Although VJ ability is assumed to be a factor in improving volleyball play, data regarding its importance in predicting success and differentiating winning from losing teams are lacking.

It is important to determine whether specific conditioning programs can help maintain or even increase jumping ability during the season. In 1 study (28), after 7 weeks of in-season heavy resistance training, a number of VJ values (e.g., height of jump, power, and velocity) failed to increase. In fact, values of approach jump and reach actually decreased from 61.2 ± 5.6 to 57.9 ± 5.3 cm. However, these 7 weeks were followed by 4 weeks of ballistic resistance training with lower loads, which led to a significant increase in those VJ measurements back to baseline values, with jump height increasing to 61.0 ± 5.6 cm. In this study, not only did traditional resistance training fail to improve jump performance, but power and velocity of jump values also actually decreased. In contrast, ballistic training increased the force, velocity, and power values of the various VJ protocols performed.

Another study (23) found a significant increase in CMJ values after an in-season 12-week ballistic-type resistance training program (including CMJs and loaded CMJs) in elite players playing in the national Division 1 in Portugal (pre: 34.22 ± 5.9 cm, post: 35.56 ± 6.3 cm). Countermovement jumps with loads of 10, 20, and 30 kg also increased significantly. Although ballistic training is important for increasing VJ, it should be performed only after a strong resistance and technique training foundation is in place. It was stressed in this study that inexperienced players should avoid jump training with heavy loads. Instead, they should focus on perfecting their jump technique and enhancing their strength and stamina.

A third study (10) found improvement in both VJ and running VJ after 12 weeks of supervised off-season training consisting of strength training (4 times per week), plyometric training (twice per week), and aerobic training (4 times per week). Vertical jump increased from 44.7 ± 5.7 to 48.0 ± 4.2 cm and running VJ increased from 47.6 ± 5.0 to 51.8 ± 5.6 cm. No changes in VJ performance were recorded after 12 extra weeks of unsupervised training.

Lastly, one study (31) found improvements in block jump and spike jump performance after 6 weeks of isokinetic resistance training in which players performed exercises at both slow and fast angular velocities. Values were reported as maximal height was reached, rather than as the difference between standing reach and maximum jump height. In addition, standard error of measurement was reported instead of *SD.* Baseline values of the block jump (267.0 ± 2.4 cm) and spike jump (280.7 ± 2.7 cm) increased to 271.7 ± 2.2 cm and 284.4±2.3, respectively. The control group was involved in volleyball practices only and showed no improvement in VJ performance.

One of the objectives of strength and conditioning coaches is to improve their players' VJ performance throughout the training program. In one study (13), no changes in VJ values were seen in players who trained for endurance and strength 1–2 times per week throughout the entire season. In contrast, VJ values increased in a group of players who trained for endurance and strength 3–4 times per week during 7 weeks of the preparation phase and 2–3 times per week during the first competition phase of their program. When strength training was interrupted for the last 5 weeks of the second competition phase, VJ decreased.

In another study (27), VJ values collected during 2 seasons in NCAA Division I female players were reported. The 2004–2005 preseason included 24 practice sessions, 12 strength training sessions, and 2 rest days within 2 weeks. Spike jump (48.8 ± 3.4 cm) and block jump (39.8 ± 3.7 cm) values were significantly reduced from baseline values (52.1 ± 2.9 and 47.5 ± 3.1 cm, respectively). When measured at the end of the season, spike jump values (54.5 ± 3.9 cm) returned to baseline, whereas block jump values increased (44.3 ± 3.7 cm) but failed to reach the baseline values. The 2005–2006 preseason included 17 practice sessions, 10 strength training sessions, and 1 rest day within 2 weeks. Spike jump and block jump values did not significantly change throughout the season. It is possible that the extra 7 practices included in the 2004–2005 preseason may have led to fatigue and to reduced performance.

Various types of ergogenic aids are used by athletes to improve VJ performance, among them compressive garments such as tights and elastic shorts. One study (18) examined whether compression garments affect jump performance. Eighteen NCAA division I players were examined on 10 maximal CMJs with hands kept on the waist throughout the jumping performances. Although the compression shorts did not influence maximal jump power, they did help maintain power production over repeated jumps. Although the reasons for the benefits of using the compression shorts were unclear, the authors of this study suggested they might be associated with the increased proprioceptive cues resulting from the tight feel of the garment. More research is needed to corroborate these findings.

Agility and Speed

Agility and speed are integral aspects of almost every defensive and offensive maneuver performed by volleyball players. Various types of agility and speed test protocols are available, and therefore, comparisons among studies can be difficult. Researchers are advised to consider specificity when choosing a test protocol from the ones available in the literature.

Two studies examined the effects of strength and conditioning programs on agility and speed in female volleyball players (10,27). In one study (10), NCAA division I starters and nonstarters underwent 12-weeks of an off-season conditioning program that included 4 weekly strength training sessions, 2 weekly plyometric sessions, and 4 weekly endurance sessions (30-minute runs at ~80% of maximal heart rate). Speed tests included 10-yd (9.1 m) and 40-yd (36.6 m) runs. A T-test–running forward for 9.1 m, shuffling left or right for 4.6 m, shuffling to the other side for 9.1 m, shuffling back 4.6 m, and back-pedaling for 9.1 m–was used to test the players' agility. Running times were measured by a handheld stopwatch. These tests were performed 2 weeks into the 12-week program and at the end of the program. The results indicated that starters preformed better on the 40-yd (36.6 m) sprint compared to nonstarters (5.56 ± 0.23 vs. 5.84 ± 0.24 seconds, respectively). However, no differences were found between starters and nonstarters in the 10-yd (9.1 m) run (1.55 ± 0.42 vs. 1.84 ± 0.09 seconds, respectively) and the agility *T*-test (10.78 ± 0.19 vs. 11.04 ± 0.44 seconds). Pooled data for both starters and nonstarters revealed that the 12-week conditioning program actually reduced performance in the agility *T*-test (pre: 10.87 ± 0.34 seconds, post: 11.16 ± 0.38 seconds), whereas no changes were observed in the 10-yd (pre: 1.67 ± 0.35 seconds, post: 1.82 ± 0.07 seconds) and 40-yd (pre: 5.67 ± 0.28 seconds, post: 5.62 ± 0.24 seconds) sprints. The authors suggested that these values probably reflected the lack of speed and agility drills during the 12-week program and that most likely strength and plyometric training alone cannot improve speed and agility.

Another study (27) examined the effectiveness of 2 weeks of preseason conditioning in 2 consecutive seasons (2004–2005, 2005–2006) in NCAA division I volleyball players. The 2004–2005 preseason included 24 practice sessions, 12 strength training sessions, and 2 rest days within 2 weeks. The 2005–2006 preseason included 17 practice sessions, 10 strength training sessions, and 1 rest day within 2 weeks. An agility *T*-test was performed before the preseason, after the preseason, and at the end of the season's competition phase. The *T*-test was performed on half of a volleyball court with running lengths similar to those described in the study by Fry et al. (10). During the 2004–2005 season, *T*-test performance deteriorated from baseline values (10.12 ± 0.5 seconds) by the end of the preseason (10.33 ± 0.7 seconds) but returned to baseline values by the end of the competition phase of the season (9.79 ± 0.5 seconds). In contrast, during the 2005–2006 season, *T*-test performance improved significantly at the end of the preseason (9.69 ± 0.6 seconds) compared to baseline values (10.01 ± 0.6) and continued to improve toward the end of the competition phase of the season (9.17 ± 0.8). These data suggest that athletes may have been overly fatigued after the 2004–2005 preseason, which included 24 practice sessions and 12 strength training sessions. In the 2005–2006 season, even though 7 fewer practices and 2 fewer strength training sessions were conducted, the athletes' performance improved.

The intensity of the preseason program can result in an imbalance between training load and recovery. Coaches should understand that too much training can lead to reduced performance. Specifically, volleyball coaches and strength and conditioning coaches should be aware of the concepts of functional overreaching, nonfunctional overreaching, and overtraining. Functional overreaching is a state in which reduced performance because of training stress eventually leads to improvement in performance after recovery. Nonfunctional overreaching is a state in which the training load is greater than the recovery allowed, and performance is reduced for a short term, usually without physiological and psychological signs. Lastly, overtraining is a state in which the increased accumulation of training with inadequate recovery leads to long-term reduced performance accompanied by physiological and psychological maladaptations (24).

Similar values of a 20-yd (18.3-m) dash were found in 3 studies (16,26,32): 3.05 ± 0.17 seconds in 180 collegiate players (16), 3.12 ± 0.13 seconds in 15 members of the 1975 US women's volleyball training team (32), and 2.98 seconds vs. 3.14 seconds in the most successful vs. the least successful players in the 1977 University of Houston Invitational Volleyball Tournament (26). In the latter study (26), 20-yd dash values were reported separately for the first 10 yd and for the next 10–20 yd. Other sprint times reported were 1.05 ± 0.05 seconds for a 5-m dash (35) and 1.68 ± 0.095 seconds for a 10-yd dash (9.91 m) (25). Also in this study (25), a comparison between volleyball and basketball players was made. It was found that basketball players were slower (1.72 ± 0.1 seconds) than volleyball players. Both volleyball and basketball players were faster than nonathletes (1.88 ± 0.13 seconds).

One study (3) used a unique testing apparatus that was made of a 6-m × 1-m platform with a built-in force platform. Twenty-nine NCAA division I–III players ran 5 m back and forth 4 times, starting and ending on the force platform. No differences in running times were found between division I–III players. Agility running times correlated significantly with CMJ heights ($r = -0.58$). In fact, jump height explained 34% of the variance in agility running times. Lastly, a discriminate analysis evaluating factors that differentiated the winning teams from the losing teams in these Divisions found agility to be an important discriminator (22).

ON-COURT PERFORMANCE

Physiological variables such as heart rate and blood lactate should be measured under field conditions so that coaches can be provided with relevant information on the physical demands of the volleyball game. Information on patterns of movements and actions performed by volleyball players during the game should be also collected and analyzed. These measurements refer to notational analysis or time–motion analysis, which are used to quantify the number and types of movements performed by the players during a game. Unfortunately, we found no studies using time–motion analysis, but 2 studies examining on-court physiological variables were discovered (7,19). Time–motion analysis in men's volleyball reveals that most rallies last less than 12 seconds, with a range of 3–40 seconds. Rest periods between rallies were also 12 seconds or less (30). Although it is appealing to think that volleyball rallies of female players are similar to those of male players, this cannot be known without performing time–motion analyses in women's games as well.

In one study (7), heart rates during volleyball practices and games were measured in 6 nonelite female players. Heart rates during practice averaged 134 $\text{b}\cdot\text{min}^{-1}$ and ranged from 120 to 161 $\text{b}\cdot\text{min}^{-1}$. During an actual game, heart rates averaged 139 $\text{b}\cdot\text{min}^{-1}$ and ranged from 116 to 172 $\text{b}\cdot\text{min}^{-1}$. Mean heart rate was the highest during spiking (138 $\text{b}\cdot\text{min}^{-1}$) and lowest while serving (104 $\text{b}\cdot\text{min}^{-1}$). For this small sample, volleyball play appeared to be only moderately strenuous, with heart rates corresponding to ~55–60% of $\dot{V}O_2$max.

In another study (19), lactate concentrations were measured in players of the first German league in 1983–1984. Lactate values did not change significantly from pre to postgame and remained around 2–2.5 $\text{mmol}\cdot\text{L}^{-1}$. It was explained by the authors of this study that during volleyball games, most of the energy requirements are supplied by phosphagen breakdown, with only a minor contribution from anaerobic glycolysis. Although this is theoretically plausible, more research is needed to understand the metabolic pathways in use during female volleyball games.

CONDITIONING FOR VOLLEYBALL

The use of data from on-court performance studies and from experiments examining methods of improving physiological variables can enable strength and conditioning coaches to create useful conditioning programs. Although a conceptualized review on conditioning programs in volleyball is beyond the scope of this article, a short overview is warranted. A recent review by Hedrick (14) suggested that a training program for high-level performance in volleyball must be specific to the requirements of volleyball. Exercise should be based on movements that will take place during a game. For example, lateral movements are often performed in volleyball, whereas most strength exercises are executed in the sagittal plane, and therefore, coaches should include exercises such as lateral squats and side lunges in their training programs. Plyometric exercises, such as lateral box jumps and lateral bounds, should also be included. In addition, dumbbell training should be considered as an important part of the conditioning program, because it improves balance and body control. Also, trunk training is essential because the game of volleyball requires movements such as running, twisting, and jumping, which can create strenuous forces on the back. Usually, trunk exercises are performed in the supine position. In volleyball, based on the principle of specificity, some of the exercises should be done standing up.

A strong trunk must be accompanied by a strong upper body. A strong upper body will allow for higher-velocity spikes and improved VJ and will help prevent injuries in the shoulder joint musculature, which is stressed in the game of volleyball. Lastly, training should aim at improving VJ, because it is one of the most important aspects of the game. In a follow-up article (15), Hedrick presented a fully detailed conditioning program based on the abovementioned principles.

METHODOLOGICAL AND MEASUREMENT CONCERNS

Based on the reviewed studies dealing with the physical attributes, physiological attributes, and on-court performances of female volleyball players, 3 methodological and measurement concerns are discussed. (a) The lack of studies using a time–motion analysis. In only 2 studies (7,19) were data obtained on physiological attributes of female volleyball players during actual games. Information on what actions players actually perform during the game, such as the number of VJ performances in defensive (e.g., blocking) and offensive (e.g., spiking) maneuvers, is crucial in developing appropriate training programs. As in other ball games (e.g., basketball [36]), more studies collecting data on on-court performances in volleyball are required. A systematic observation of the main actions demonstrated by volleyball players during games should be carefully conducted, and an in-depth analysis of the performed on-court performances should be undertaken. By understanding the physiological demands of volleyball players during a game, strength and conditioning coaches can effectively plan their strength and conditioning programs, matching them to the specific needs of each player. (b) The lack of experimental studies. In recent reviews of observational and experimental studies on physical attributes and physiological characteristics (36) and VJ (37) of female and male basketball players, it was argued that more studies should encourage implementation of conditioning programs for agility and speed, and for power and strength, with at least one intervention group and one control. This observation can also be made based on the current review of female volleyball players. Only 4 studies were found to examine the contribution of a resistance training program to strength parameters (10,13,23,31). More multigroup studies are needed to compare the effectiveness of the different strength and conditioning programs given to female volleyball players. The knowledge emerging from these studies will help coaches assess the contribution of different programs to the development of their players and assist them in better matching the program to the specific needs of the individual player. (c) The use of multiple testing protocols and settings. Various tests examining physiological attributes were used in the reviewed studies, among them being agility and speed and VJ tests. To compare data from different studies, it is essential to know the specific protocol of the test and its selected testing device and setting. In addition, norms established based on the results of one physical test cannot be used to assess results achieved in another test. Therefore, a careful selection of the testing protocol and device should be made. For example, if the objective of the researcher is to study the jumping ability of the players in spiking, then a jumping test allowing approach and the use of hands should be selected. In this case, the test should mimic the unique actions demonstrated by the player while jumping in an actual game.

PRACTICAL APPLICATIONS

Based on the reviewed studies, 3 practical implications are suggested for volleyball coaches and strength and conditioning coaches who work with female volleyball players. (a) The amount of training should be carefully monitored when planning strength and conditioning programs. To achieve a high level of proficiency in volleyball, a proper balance between volume and intensity of training is required, and appropriate rest periods between training sessions. If the correct balance between volume, intensity, and frequency of training does not exist, overreaching and overtraining can occur. Although functional overreaching can lead to an eventual increased performance, both nonfunctional overreaching and overtraining can lead to diminished performance for short and long periods of time. Making a differential diagnosis between nonfunctional overreaching and overtraining is difficult and depends on clinical outcomes. However, a key term in the recognition of overtraining is “prolonged maladaptation” of the athlete and of several biological regulation mechanisms (24). Overtraining is also characterized by diminished performance, increased fatigue, and stress (34), and therefore maintaining the balance between training and recovery is essential in monitoring the players’ activities during the annual training program (see a review by Meeusen et al. on overreaching and overtraining [24]). (b) The volleyball program should include ballistic-type or plyometric training (i.e., *power training*). As indicated in the current review, traditional resistance training is not enough to improve the performances of female volleyball players, especially those that comprise VJ–blocking, serving, and spiking. Therefore, explosive-type strength training and plyometric training in particular should be included in the training program to enable the players to improve their leg muscle power in the overall conditioning program. (c) Prevention of injury should be considered when planning conditioning programs. For example, as suggested by Marques et al. (23), inexperienced players should avoid jump training with heavy loads and should focus on enhancing strength and improving jumping technique. Only after a strong foundation in strength training is achieved should ballistic training begin. In another example, patellar tendinopathy (i.e., jumper's knee) is an overuse injury that can be caused by an increase in the volume of jumping training and occurs more frequently when athletes practice on hard, unforgiving surfaces (29). Therefore, the type of surface on which the athletes practice is of considerable importance.

ACKNOWLEDGMENTS

The authors would like to thank Dinah Olswang for her editorial assistance during the preparation of this manuscript. No sources of funding were used to assist in the preparation of this review. The authors have no conflicts of interest that are directly relevant to the content of this review.

REFERENCES

1. Alfredson, H, Pietila, T, and Lorentzon, R. Concentric and eccentric shoulder and elbow muscle strength in female volleyball players and non-active females. *Scand J Med Sci Sports* 8: 265–270, 1998.
2. Amasay, T. Static block jump techniques in volleyball: Upright versus squat starting positions. *J Strength Cond Res* 22: 1242–1248, 2008.
3. Barnes, JL, Schilling, BK, Falvo, MJ, Weiss, LW, Creasy, AK, and Fry, AC. Relationship of jumping and agility performance in female volleyball athletes. *J Strength Cond Res* 21: 1192–1196, 2007.
4. Bayios, IA, Bergeles, NK, Apostolidis, NG, Noutsos, KS, and Koskolou, MD. Anthropometric, body composition and somatotype differences of Greek elite female basketball, volleyball and handball players. *J Sports Med Phys Fitness* 46: 271–280, 2006.
5. Cardinale, M and Lim, J. Electromyography activity of vastus lateralis muscle during whole-body vibrations of different frequencies. *J Strength Cond Res* 17: 621–624, 2003.
6. Coutts, KD. Leg power and Canadian female volleyball players. *Res Q* 47: 332–335, 1976.
7. Fardy, PS, Hritz, MG, and Hellerstein, HK. Cardiac responses during women's intercollegiate volleyball and physical fitness changes from a season of competition. *J Sports Med Phys Fitness* 16: 291–300, 1976.
8. Ferris, DP, Signorile, JF, and Caruso, JF. The relationship between physical and physiological variables and volleyball spiking velocity. *J Strength Cond Res* 9: 32–36, 1995.
9. Fleck, SJ, Case, S, Puhl, J, and Van Handle, P. Physical and physiological characteristics of elite women volleyball players. *Can J Appl Sport Sci* 10: 122–126, 1985.
10. Fry, AC, Kraemer, WJ, Weseman, CA, Conroy, BP, Gordon, SE, Hoffman, JR, and Maresh, CM. The effects of an off-season strength and conditioning program on starters and non-starters in women's intercollegiate volleyball. *J Appl Sport Sci Res* 5: 174–181, 1991.
11. Gladden, LB and Colacino, D. Characteristics of volleyball players and success in a national tournament. *J Sports Med Phys Fitness* 18: 57–64, 1978.
12. Gualdi-Russo, E and Zaccagni, L. Somatotype, role and performance in elite volleyball players. *J Sports Med Phys Fitness* 41: 256–262, 2001.
13. Häkkinen, K. Changes in physical fitness profile in female volleyball players during the competitive season. *J Sports Med Phys Fitness* 33: 223–232, 1993.
14. Hedrick, A. Training for high level performance in women's collegiate volleyball: Part I training requirements. *Strength Cond J* 29: 50–53, 2007.
15. Hedrick, A. Training for high level performance in women's collegiate volleyball: Part II training program. *Strength Cond J* 30: 12–21, 2008.
16. Hosler, WW, Morrow, JR Jr, and Jackson, AS. Strength, anthropometric, and speed characteristics of college women volleyball players. *Res Q* 49: 385–388, 1978.
17. Johnson, GO, Nebelsick-Gullett, LJ, Thorland, WG, and Housh, TJ. The effect of a competitive season on the body composition of university female athletes. *J Sports Med Phys Fitness* 29: 314–320, 1989.
18. Kraemer, WJ, Bush, JA, Bauer, JA, Triplett-McBride, NT, Paxton, NJ, Clemson, A, Koziris, LP, Mangino, LC, Fry, AC, and Newton, RU. Influence of compression garments on vertical jump performance in NCAA division I volleyball players. *J Strength Cond Res* 10: 180–183, 1996.
19. Kunstlinger, U, Ludwig, HG, and Stegemann, J. Metabolic changes during volleyball matches. *Int J Sports Med* 8: 315–322, 1987.
20. Lawson, BR, Stephens, TM, Devoe, DE, and Reiser, RF. Lower-extremity bilateral differences during step-close and no-step countermovement jumps with concern for gender. *J Strength Cond Res* 20: 608–619, 2006.
21. Malousaris, GG, Bergeles, NK, Barzouka, KG, Bayios, IA, Nassis, GP, and Koskolou, MD. Somatotype, size and body composition of competitive female volleyball players. *J Sci Med Sport* 11: 337–344, 2008.
22. Marey, S, Boleach, LW, Mayhew, JL, and McDole, S. Determination of player potential in volleyball: Coaches' rating versus game performance. *J Sports Med Phys Fitness* 31: 161–164, 1991.
23. Marques, MC, Tillaar, R, Vescovi, JD, and Gonzalez-Badillo, JJ. Changes in strength and power performance in elite senior female professional volleyball players during the in-season: A case study. *J Strength Cond Res* 22: 1147–1155, 2008.
24. Meeusen, R, Duclos, M, Gleeson, M, Rietjens, G, Steinacker, J, and Urhausen, A. Prevention, diagnosis and treatment of the overtraining syndrome. *Eur J Sport Sci* 6: 1–14, 2006.
25. Morrow, JR Jr, Hosler, WW, and Nelson, JK. A comparison of women intercollegiate basketball players, volleyball players and non-athletes. *J Sports Med Phys Fitness* 20: 435–440, 1980.
26. Morrow, JR Jr, Jackson, AS, Hosler, WW, and Kachurik, JK. The importance of strength, speed, and body size for team success in women's intercollegiate volleyball. *Res Q* 50: 429–437, 1979.
27. Nesser, TW and Demchak, TJ. Variations of preseason conditioning on volleyball performance. *J Exerc Phys Online* 10: 35–42, 2007.
28. Newton, RU, Rogers, RA, Volek, JS, Hakkinen, K, and Kraemer, WJ. Four weeks of optimal load ballistic resistance training at the end of season attenuates declining jump performance of women volleyball players. *J Strength Cond Res* 20: 955–961, 2006.
29. Reeser, JC, Verhagen, E, Briner, WW, Askeland, TI, and Bahr, R. Strategies for the prevention of volleyball related injuries. *Br J Sports Med* 40: 594–600; discussion 599–600, 2006.
30. Sheppard, JM, Gabbett, T, Kristie-Lee, T, Dorman, J, Lebedew, AJ, and Borgeaurd, R. Development of repeated-effort test for elite men's volleyball. *Int J Sports Physiol Perf* 2: 292–304, 2007.
31. Smith, DJ, Stokes, S, and Kilb, B. Effects of resistance training on isokinetic and volleyball performance measures. *J Appl Sport Sci Res* 1: 42–44, 1987.

32. Spence, DW, Disch, JG, Fred, HL, and Coleman, AE. Descriptive profiles of highly skilled women volleyball players. *Med Sci Sports Exerc* 12: 299–302, 1980.
33. Stech, M and Smulsky, V. The estimation criteria of jump actions of high performance female volleyball players. *Res Yearbook* 13: 77–81, 2007.
34. Urhausen, A, Gabriel, H, and Kindermann, W. Blood hormones as markers of training stress and overtraining. *Sports Med* 20: 251–276, 1995.
35. Wnorowski, K. Relations between technical-tactical competence and speed-force skills in women volleyball players. *Res Yearbook* 13: 226–229, 2007.
36. Ziv, G and Lidor, R. Physical attributes, physiological characteristics, on-court Performances, and nutritional strategies of female and male basketball players *Sports Med* 39: 547–568, 2009.
37. Ziv, G and Lidor, R. Vertical jump in female and male basketball players–A review of observational and experimental studies. *J Sci Med Sport* doi:10.1016/j.jsams. 2009. 02.009.