Incidence of acute volleyball injuries: a prospective cohort study of injury mechanisms and risk factors

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The purpose of the study was to examine the incidence and mechanisms of acute volleyball injuries, with particular reference to possible risk factors for ankle injuries. Coaches and players in the top two divisions of the Norwegian Volleyball Federation were asked to keep records of exposure time and all acute volleyball injuries causing a player to miss at least one playing day during one season. We found 89 injuries among 272 players during 51 588 player hours, 45 837 h of training and 5751 h of match play. The total injury incidence was 1.7±0.2 per 1000 h of play, 1.5±0.2 during training and 3.5±0.8 during match play. The ankle (54%) was the most commonly injured region, followed by the lower back (11%), knee (8%), shoulder (8%) and fingers (7%). Of the ankle injuries, 79% were recurrences, and the relative risk of injury was 3.8 ($P<0.0001$) for previously injured ankles (38 of 232) vs. non-injured ankles (10 of the 234). Moreover, a reinjury was observed in 21 of the 50 ankles that had suffered an ankle sprain within the last 6 months (42.0±7.0%; risk ratio: 9.8 vs. uninjured ankles; $P<0.000001$). The data indicate that external supports should be worn for 6–12 months after an ankle sprain and that specific injury prevention programs may be developed for ankle sprains in volleyball.

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Volleyball is among the most popular sports in the world, with more than 200 member countries in the Fédération Internationale de Volley-Ball (FIVB) and about 150 million players. In Norway, volleyball is the eight largest sport with about 33 000 registered players. Considering the popularity of the sport, there is a lack of information about volleyball injuries and their mechanisms.

Since volleyball is a non-contact game, where players from the opposing teams are separated by the net, it may be expected that the incidence of injuries is low. Schafle et al. (1) found an overall injury incidence of 2.3 per 1000 hours during the United States Volleyball Association's (USVBA) 6-day national tournament. An injury was defined as one causing at least 1 day of missed participation, and both overuse injuries and acute injuries were included in their estimate (1). In a recent retrospective study on Norwegian elite volleyball the incidence of acute ankle sprains was estimated to 0.9 per 1000 hours (2). However, we do not have reliable information from sea-son-long prospective studies on the injury incidence during training and games in volleyball.

Previous studies have indicated that ankle sprains may be the most common injury type in volleyball, accounting for one-quarter to one-half of all acute injuries (1, 3–6). We also have some evidence that these injuries mainly occur at the net, when landing after blocking or attacking (2). Although we have some information about injury mechanisms on which to form hypotheses about possible intervention strategies, we know less about individual risk factors.

Our previous study also showed that in 78% of the cases, the players had a history of at least one previous ankle injury during their career (2). However, since we did not have any information on the uninjured players, this study could not establish the role of previous injury as an independent risk factor. We therefore wanted to study the effects of previous ankle injury as a risk factor for new ankle sprains using a prospective season-long study on a population of high-level volleyball players. With this design

we also wanted to examine the incidence and mechanisms of other acute volleyball injuries.

Material and methods

A prospective cohort study of acute injuries in the Norwegian Volleyball Federation (NVBF) league was carried out during the 1992–93 indoor season. The NVBF league consists of amateur teams from all of Norway. The teams are separated into six divisions according to their level of play. Before the start of each season, the coaches of the teams in the two top men's and women's divisions were invited to include their teams in the study. From a total of 28 teams (14 men's and 14 women's teams), 26 teams (13 men's and 13 women's) agreed to take part in the study. The matches were played with equipment and rules in accordance with the regulations of the NVBF and FIVB (7).

Before the season started, all players listed on the team roster by their coaches were asked to complete pre-participation forms including information on previous playing experience (division, number of years, national team participation), number of previous injuries to right and left ankle, time since last injury and regular use of ankle protection for their right and left ankles (tape or brace).

During 6 months of the main competition period (September–February) of the season, the coaches were asked to complete a monthly team information form that included questions on the number of training hours the preceding month, the participation rate during training (estimated average percentage of players present during practice), and the duration of matches played (duration of each match to the nearest half-hour; including non-conference games and tournaments). Incomplete forms were followed up by telephone interviews and all the team information forms were completed for the teams included in the study.

All acute injuries during organized volleyball training or matches were also reported by the coaches on the monthly team information forms. An injury was registered if it resulted from a sudden event during organized volleyball training or match, and caused an absence of one or more days of training or match play. All the injured players consented to participate in a telephone interview. Among the information requested in each case were personal data, previous injuries, use of ankle protection devices (tape or brace), mechanism of injury, court position, skill performed, and time of absence from training. The terminology for description of court positions, skills and player function has been described previously (2). The skill terminology is internationally accepted and familiar to the players, and was not defined in the form answered by the players.

Calculations and statistical methods

The total training exposure each month was calculated for every team as the number of hours of training, multiplied by the participation rate, multiplied by the number of players on the team roster. The total match exposure each month was calculated for every team as the sum of the duration of each match, multiplied by six players. Injury incidence was calculated as the number of acute injuries reported per 1000 hours of play (match and/or training, as appropriate). When calculating injury risk in relation to possible risk factors known from the pre-participation forms, each ankle was considered as a separate case ($n=466$ ankles). The injury risk was expressed as the number of ankles injured as a percentage of the total number. Results are given as means$\pm$SE unless otherwise noted. Comparisons of activity type (match vs. training), and gender were done using the Mantel–Haenszel test for cohort data with a person–time denominator (8). Comparisons of the various risk factors were done using simple chi-square statistics. Fisher's exact test was used when the number of cases was five or less.

Results
Player and team information

A total of 273 players (143 women and 130 men) was registered on the teams taking part in the study, and we received 233 pre-participation forms. The response rate was 86% for men and 85% for women. The mean age of the players was 23.1$\pm$4.2 years (SD) for men and 21.7$\pm$4.4 for women, and 88% of the players had previously played at least one season at the same division level. The total exposure time was 51 588 h, 45 837 h of training (7.2 h/week for men and 6.9 h/week for women) and 5751 h of match play (1.6 h/week for men and 1.4 h/week for women).

Injury incidence

The coaches reported 89 acute injuries, and the overall injury incidence was estimated to be 1.7$\pm$0.2 per 1000 player hours (Table 1). Among the men, we observed an increased incidence during match play compared to training, whereas no such effect was observed for the women (Table 1).The distribution of injured body regions is shown in Fig. 1. Sprains (65%) and strains (11%) were the most frequent types of injury. The most frequent injury type observed was the ankle sprain ($n=48$, 54% of all injuries), with an overall incidence of 0.9$\pm$0.1 per 1000 player hours (Table 1). Again, we observed an increased incidence during competition for men, but not for women (Table 1).

The severity of injuries was judged by the time of

Tables 1. Injury incidence (±SE) for all injuries and ankle injuries during training and match play for men and women in the competition period (September–February) of the 1992–93 indoor season. RR, relative risk

	Total injury incidence	Injury incidence match	Injury incidence training	RR (match vs. training)
All injuries				
Men	1.7±0.3	3.9±1.1	1.5±0.2	2.7 ($P<0.01$)
Women	1.7±0.3	3.0±0.5	1.6±0.3	1.9 (NS)
Total	1.7±0.2	3.5±0.8	1.5±0.2	2.3 ($P<0.001$)
RR (men vs. women)	1.0 (NS)	1.3 (NS)	0.9 (NS)	
Ankle injuries				
Men	1.0±0.2	2.6±0.9	0.8±0.2	3.2 ($P<0.01$)
Women	0.8±0.2	0.7±0.3	0.9±0.2	0.9 (NS)
Total	0.9±0.1	1.7±0.6	0.8±0.1	2.1 ($P<0.05$)
RR (men vs. women)	1.2 (NS)	3.5 (NS)	1.0 (NS)	

absence from match/training (Fig. 2). In 33% of the cases, most of which were knee, back and ankle injuries, the players were absent for more than 2 weeks after injury. Of the ankle injuries, 26% were seen by a physician and 39% were treated by a physical therapist.

Mechanisms and risk factors

Of the injuries that could be related to a specific court position, 89% occurred at the net. Ankle injuries occurred mainly when landing after blocking; most other injuries were associated with take-off, landing or the actual spiking motion during attack (Fig. 3). Specifically, 68% of the ankle sprains were caused by a player landing on the foot of an opponent, whereas 19% resulted from landing on a team mate's foot.

In 79% of the cases of ankle sprains, the player had injured the same ankle before. A new ankle injury was seen in 10 of the 234 ankles without previous injury (4.3±1.3%), whereas a reinjury was observed in 38 of the 232 previously injured ankles (16±2.4%; risk ratio 3.8 vs. uninjured ankles; $P<0.0001$). However, the primary group at risk appeared to be those who had suffered an injury within the last 6 months,

where a reinjury was observed in 21 of 50 ankles (42±7.0%; risk ratio 9.8 vs. uninjured ankles; $P<0.0001$). The reinjury risk was also increased during the 6–12 month period after a previous injury (24% reinjury risk; risk ratio 5.6 vs. uninjured ankles; $P<0.0001$).

No significant relationship was observed between risk of ankle injury and age, experience (total number of years playing volleyball or years playing on the same level), skill level (national team players vs. others) or player function (setter, middle blocker, outside hitter or utility player). Also, on a team basis there was no relationship between the incidence of ankle injuries and training level (number of hours of training per week or match to training ratio).

The players reported that they intended to use ankle braces or tape regularily on 11% of the total number of ankles involved. The proportion of players who reported use of ankle protection was higher among players with previous ankle injury (20%) than among those with previously uninjured ankles (0.9%,
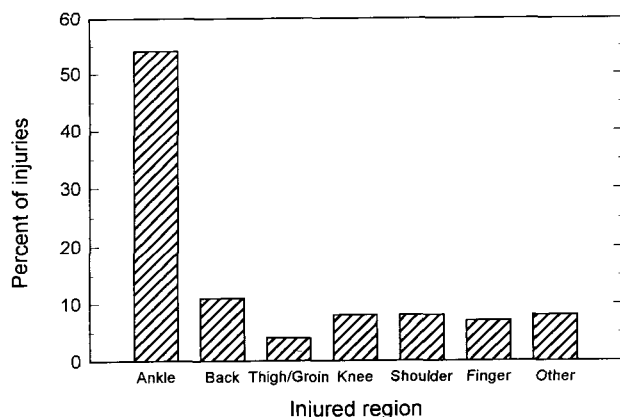

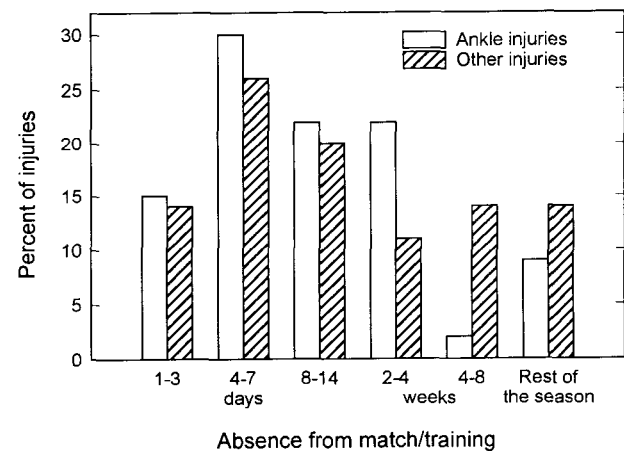*Fig. 1.* Distribution of injuries by body region (n=89).

Fig. 2. Distribution of duration of absence from training/match play (n=81) shown separately for ankle injuries and other injuries. In seven cases we could not obtain information on the time of absence from training.
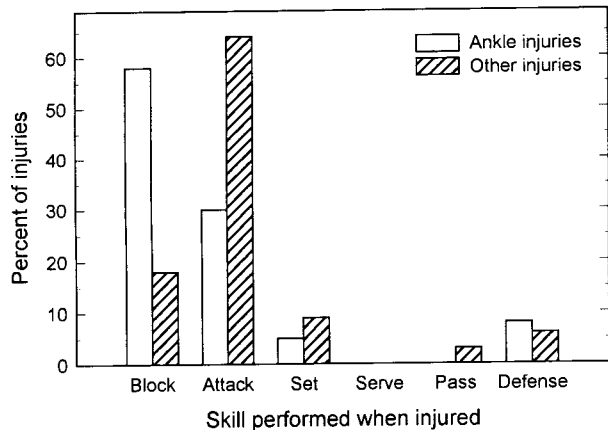
Fig. 3. Mechanism of injury illustrated by skill performed when injured, shown separately for ankle injuries ($n=40$) and other injuries ($n=33$). In 16 cases the injury could not be related to a specific skill.

$P<0.0001$). In six of the cases, the players reported that they were wearing an ankle brace when they were injured. All of these had previously injured their ankle, four of them five or more times before.

Discussion

The main observations of this study were that (i) there were 1.7 ± 0.2 acute injuries per 1000 player hours in volleyball; (ii) about one half of these injuries were ankle sprains; and (iii) players with previous ankle injuries had an increased risk of reinjury, particularly during the first 12 months after a previous sprain.

Injury incidence and injury types

Schafle et al. (1), in a prospective study including overuse and acute injuries during 6 days of tournament play (USVBA national tournament), found an injury incidence of 2.3 per 1000 hours, when only injuries causing at least 1 day of missed participation were included. The authors cautioned that two factors may have contributed to a higher than normal injury incidence: the intensive tournament format may have exacerbated overuse injuries that otherwise were kept at a tolerable level during the season, and reporting may have been high because of the ready availability of prefessional care. Nevertheless, their estimate was lower than the incidence during competition observed in the present study, which was 3.5 ± 0.8 per 1000 hours and which does not include overuse injuries. Another study from Scandinavia estimated injury incidence during games to 5.7 per 1000 hours including overuse injuries, but this estimate was based on one club through one season only (6).

Training injury incidence has been estimated to

about two injuries per 1000 hours in two studies from Danish elite volleyball using injury definitions similar to the present (6, 9). These estimates also included overuse injuries, but even so they are only slightly higher than the present result of 1.5 ± 0.2 per 1000 hours. This is not surprising, since many overuse injuries do not keep the players from participating in training or games. In fact, most players with jumper's knee, the most common overuse injury in volleyball, still manage to take part in training and games (10).

Volleyball is a non-contact sport and since opposing teams are separated by the net, it may be postulated that injury incidence is low. When comparing with other team sports, it is important to compare player populations with a similar training background and skill level, and it is critical that the definition of injury is the same. There are studies available from elite Scandinavian team handball (11), soccer (12), basketball (13) and ice hockey (14) which have used the same injury definition as the present. While the overall injury incidence in the present study was 1.7 ± 0.2 per 1000 hours, Colliander et al. (13) found that the injury incidence in Swedish basketball was 2.5 per 1000 hours among men and 2.9 among women in a retrospective season-long survey including 191 players. Ekstrand & Tropp (12) followed 135 players in the top division in Sweden prospectively for one season, and found that the injury incidence in the top division was 4.6 ± 1.7 per 1000 hours during training and 21.8 ± 11.3 during games (overall incidence: 8.6 ± 3.3). Jørgensen (11) studied 288 handball players in Denmark in a post-season enquete and estimated the overall injury incidence to be 8.3 per 1000 hours (11). Finally, Lorentzon et al. (14) followed an elite Swedish ice hockey team prospectively for 3 years and reported an injury incidence of 1.4 per 1000 practice hours and 78.4 per 1000 game hours (14). From this comparison it may be concluded that the incidence of injuries rate in volleyball is similar to or slightly lower than in basketball, and notably lower than that found in soccer, handball and ice hockey.

The incidence of ankle injuries was 0.9 ± 0.1 per 1000 hours, the same result as in a previous retrospective study (2). Ankle injuries accounted for roughly half of all acute injuries recorded in the present study, and previous studies have shown that ankle sprains account for one-quarter to one-half of all acute injuries in volleyball (1, 3–6, 15, 16). In general, the proportion of ankle injuries is higher in studies including acute trauma only (5, 15, 16) and lower in studies including overuse injuries (1, 4, 17).

Knee injuries are of increasing concern in many sports, and in particular there is concern about the comparatively high incidence of anterior cruciate ligament injuries among women in some sports (18). Volleyball may also cause significant knee injuries (19). However, there appears to be less reason for

concern as in sports such as team handball (20), as the incidence of knee injuries was low in the present study (0.1 per 1000 hours) and most were minor (no anterior cruciate ligament injuries). The proportion of knee injuries was only 8%, the same as other acute trauma studies (5, 15, 16). In studies including overuse injuries the proportion of knee injuries is relatively higher, and this may be explained by the high prevalence of patellar tendon overuse injuries (10, 21, 22). Overuse injuries to the shoulder are also frequent in volleyball (23, 24).

In our clinical experience, finger sprains are also frequent in volleyball, but in the present study finger injuries only accounted for 7% of all injuries. Bhairo et al. (15), in the largest case series for volleyball published to date, found that finger injuries accounted for 24% of 1003 injuries. One reason for this apparent discrepancy is that, in most cases, players use sports tape to be able to continue training after finger injuries, and these injuries are therefore not recorded using an injury definition based on absence from training or games. Still, the same injuries may be overrepresented in a trauma department case series since athletes with finger sprains often report to get X-rays in order to rule out bone injury.

Injury mechanisms and risk factors

This study clearly shows that the most frequent acute injury type in volleyball is ankle sprains. It is therefore of particular interest to examine the injury mechanisms and risk factors associated with ankle sprains in detail in order to develop a prevention strategy. This study confirms and extends the findings of a previous study that the two main injury mechanisms for ankle sprains in volleyball are players landing on the foot of an opponent in the conflict zone under the net (blocker on attacker or vice versa) or a player landing on the foot of a team mate when landing from a two-man block (2). One high-risk situation that commonly occurs is when an attacker gets a 'tight' set, a ball set too low, too quick and too close to the net. In trying to reach the ball in this situation, many players try to outjump the ball, risking a landing on or across the center line, which may result in a foot conflict with the opposing blocker. The injury mechanisms associated with other injuries are less uniform, but also mainly associated with the most powerful actions in volleyball: blocking and spiking.

A previous study on soccer players with different skill and training levels showed that injury incidence was inversely related to training level (25). Teams with a high training to match ratio experienced less injuries. However, injury incidence was not related to training level in this group of volleyball players, nor was it related to the player's experience or volleyball skill level (national player or not). This suggests that specific technical training may be necessary to prevent injury in high-level athletes.

An important finding in this study was that the risk of reinjury for a previously injured ankle was increased fourfold compared to ankles without previous injury, and that almost half of all players with an ankle injury suffered a reinjury within the first 6–12 months after injury. The results also showed that four out of five injuries occurred in previously injured ankles, an observation previously made in volleyball (2) and other sports as well (12, 26). This study therefore clearly shows that players have a profoundly increased risk of reinjury during the first year after an ankle injury. The reason for this prolonged period of increased risk may be that the ligament takes at least 6 months to heal properly and regain normal strength, but it may also be due to reduced proprioceptive function post-injury. Proprioceptive function, recorded as peroneal reaction time to a sudden ankle tilt, has been shown to be attenuated in patients with chronic lateral instability (27–29), but it has not been studied during recovery from acute ankle injuries. The present data suggest that there may be an impairment in ligament strength or proprioceptive function for as long as 12 months after an acute injury, and that some form of external ankle support (tape or brace) should be recommended during this period. A recent study on soccer players demonstrates that bracing can be effective in preventing injuries in previously injured athletes (30). In addition, the results also indicate that many of the injuries had not been treated professionally, and proper rehabilitation would probably reduce the risk of reinjury.

Based on this evidence on injury mechanisms and risk factors, four main intervention strategies may be formulated (2): (i) specific technical training on take-off and landing technique during attack and two-man blocking; (ii) rule changes to reduce the conflict zone under the net where an attacker may land on a blocker's foot and vice versa (1, 2, 5); (iii) use of tape or semiflexible orthoses as ankle protection; and (iv) proprioceptive training after ankle injury. An injury prevention program has been developed based on these suggestions, which is presented in a separate paper (31).

Conclusion

Ankle sprains are the most common injuries in volleyball, accounting for about half of all injuries and with an incidence of about one per 1000 player hours. Ankle sprains mainly result from technical errors during take-off and landing after blocking and attacking, but previous ankle injury is the main risk factor. During the first 6–12 months after a previous sprain there is a six- to 10-fold increase in injury risk.

This information may be used to develop injury prevention programs specifically for volleyball.

Acknowledgements

References

1. Schafle MD, Requa RK, Patton WL, Garrick JG. Injuries in the 1987 National Amateur Volleyball Tournament. Am J Sports Med 1990: 18: 624–31.
2. Bahr R, Lian Ø, Karlsen R, Øvrebø RV. Incidence and mechanism of acute ankle inversion injuries in volleyball – a retrospective cohort study. Am J Sports Med 1994: 22: 601–4.
3. Gangitano R, Pulvirenti A, Ardito S. Lesioni traumatiche da pallavolo: Rilievi clinico-statistici. It J Sports Traumatol 1981: 3: 31–4.
4. Gerberich SG, Luhman S, Finke C, Priest JD, Beard BJ. Analysis of severe injuries associated with volleyball activities. Phys Sports Med 1987: 15: 75–9.
5. Hell H, Schönle C. Ursachen und Prophylaxe typischer Volleyballverletzungen. Z Orthopaedische 1985: 123: 72–5.
6. Yde J, Nielsen AB. Epidemiological and traumatological analyses of injuries in a Danish volleyball club. Ugeskr Læger 1988: 150: 1022–3.
7. Anonymous. Official volleyball rules. Lausanne: Fédération Internationale de Volley-Ball, 1989: 25.
8. Elwood JM. Causal relationships in medicine. Oxford: Oxford Medical Publications, 1988: 134–135.
9. Schmidt-Olsen S, Jørgensen U. Skademønster i dansk elite-volleyball. Ugeskr Læger 1987: 149: 473–4.
10. Lian Ø, Holen KJ, Engebretsen L, Bahr R. Relationship between symptoms of jumper's knee and the ultrasound characteristics of the patellar tendon among high-level male volleyball players. Scand J Med Sci Sports 1996: 6: 291–296.
11. Jørgensen U. Epidemiology of injuries in typical Scandinavian team sports. Br J Sports Med 1984: 18: 59–63.
12. Ekstrand J, Tropp H. The incidence of ankle sprains in soccer. Foot Ankle 1990: 11: 41–4.
13. Colliander E, Eriksson E, Herkel M, Skold P. Injuries in Swedish elite basketball. Orthoped 1986: 9: 225–7.
14. Lorentzon R, Wedrén H, Pietelä T. Incidence, nature and causes of ice hockey injuries. Am J Sports Med 1988: 16: 392–6.
15. Bhairo NH, Nijsten MWN, van Dalen KC, ten Duis H-J. Hand injuries in volleyball. Int J Sports Med 1992: 13: 351–4.
16. Solgård L, Nielsen AB, Møller-Madsen B, Jacobsen BW, Yde J, Jensen J. Volleyball studies presenting in casualty: a prospective study. Br J Sports Med 1995: 29: 200–4.
17. Watkins J, Green BN. Volleyball injuries: a survey of injuries of Scottish National League male players. Br J Sports Med 1992: 26: 135–7.
18. Arendt E, Dick R. Knee injury patterns among men and women in collegiate basketball and soccer: NCAA data and review of literature. Am J Sports Med 1995: 23: 694–701.
19. Ferretti A, Papandrea P, Conteduca F, Mariani PP. Knee ligament injuries in volleyball players. Am J Sports Med 1992: 20: 203–7.
20. Myklebust G, Maehlum S, Engebretsen L, Strand T, Solheim E. Registration of cruciate ligament injuries in Norwegian top level handball. A prospective study covering two seasons. Scand J Med Sci Sports 1997: in press.
21. Ferretti A, Puddu G, Mariani PP, Neri M. Jumper's knee: an epidemiological study of volleyball players. Phys Sports Med 1984: 12: 97–103.
22. Kujala UM, Friberg O, Aalto T, Kvist M, Österman K. Lower limb asymmetry and patellofemoral joint incongruence in the etiology of knee exertion injuries in athletes. Int Sports Med 1987: 8: 214–20.
23. Ferretti A, Cerullo G, Russo G. Suprascapular neuropathy in volleyball players. J Bone Joint Surg 1987: 69A: 260–3.
24. Holzgraefe M, Kukowski B, Eggert S. Prevalence of latent and manifest suprascapular neuropathy in high-performance volleyball players. Br J Sports Med 1994: 28: 177–9.
25. Ekstrand J. Soccer injuries and their prevention. Academic dissertation No. 130. Linköping: Linköping University Medical Dissertations, 1982.
26. Milgrom C, Shlamkovitch N, Finestone A et al. Risk factors for lateral ankle sprains: a prospective study among military recruits. Food Ankle 1991: 12: 26–30.
27. Löfvenberg R, Kärrholm J, Sundelin G, Ahlgren O. Prolonged reaction time in patients with chronic lateral instability of the ankle. Am J Sports Med 1995: 23: 414–7.
28. Konradsen L, Ravn JB. Ankle instability caused by prolonged peroneal reaction time. Acta Orthop Scand 1990: 61: 388–90.
29. Karlsson J, Kälebo P, Goksör L-Å, Thomée R, Swärd L. Partial rupture of the patellar ligament. Am J Sports Med 1992: 20: 390–4.
30. Surve I, Schwellnus MP, Noakes T, Lombard C. A fivefold reduction in the incidence of recurrent ankle sprains in soccer players using the Sport-Stirrup orthosis. Am J Sports Med 1994: 22: 601–6.
31. Bahr R, Lian Ø, Bahr IA. A twofold reduction in the incidence of acute ankle sprains in volleyball after the introduction of an injury prevention program: a prospective cohort study. Scand J Med Sci Sports 1997: 7: 172–7.