Recreational Soccer Can Improve the Reflex Response to Sudden Trunk Loading Among Untrained Women

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Abstract

Pedersen, MT, Randers, MB, Skotte, JH, and Krustrup, P. Recreational soccer can improve the reflex response to sudden trunk loading among untrained women. *J Strength Cond Res* 23(9): 2621–2626, 2009—A slower reflex response to sudden trunk loading (SL) has been shown to increase future risk of low back injuries in healthy subjects, and specific readiness training can improve the response to SL among healthy subjects. The purpose of the study was to investigate the effect of recreational soccer training on the reaction to SL among untrained healthy women. Thirty-six healthy, untrained, Danish women (age 19–45 years) were randomly assigned to a soccer group (SO, $n = 19$) and a running group (RU, $n = 17$). In addition, an untrained control group (CON, $n = 10$) was recruited. Training was performed for 1 hour twice a week (mean heart rate of 165 $b \cdot min^{-1}$ in SO and 164 $b \cdot min^{-1}$ in RU) for 16 weeks. Test of reactions to sudden unexpected trunk loading was performed before and after the training period. Furthermore, time-motion analysis of the soccer training was performed for 9 subjects. Group assignment was blinded to the test personnel. Physical education students organized the training. During 1 hour of soccer training, the total number of sudden moves including sudden loading of the upper body (e.g. turns, stops, throw-ins, headers, and shoulder tackles) was 192 (63). In SO, time elapsed until stopping of the forward movement of the trunk (stopping time) decreased ($p < 0.05$) by 15% and distance moved after unexpected SL decreased ($p < 0.05$) by 24% compared with no changes in RU and CON. In conclusion, football training includes a high number of sudden loadings of the upper body and can improve the reflex response to SL. The faster reflex response indicates that soccer training can reduce the risk of low back injuries.

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Introduction

Cholewicki et al. (5) demonstrated that an impaired reflex response to sudden trunk loading (SL) in previously healthy subjects increased their future risk of subsequent low back injuries. The authors concluded that future research should focus on the ability to improve muscle response to SL. It has been shown that it is possible to improve back muscle response to SL among patients with low back injuries (11). In a recent intervention study (17) among healthy employees working at a geriatric ward (orderlies, nursing aides, physiotherapists, and occupational therapists), the results showed that after 9 weeks of training, 2 hours a week with focus on reactions to a variety of SL (readiness training), the reaction to sudden unexpected back loading was markedly changed (17). Stopping time decreased and the distance moved before stopping were also significantly reduced. Additionally, a 1-year follow-up showed a high sustainability of the training effect (17). Reduced stopping time and a shorter distance moved before stopping are considered to reduce the individual risk of low back injuries by decreasing the amount of energy accumulated before the slowing down of a forward movement of the trunk, which is in line with the results of Cholewicki et al. (5). In addition, a faster reaction implies an earlier stabilization of the spine (6).

In our previous studies (16,17), training had no significant effect on the response characteristics to an expected SL. Instead, training improved the reaction to an unexpected SL to an extent that apparently eliminated the normal difference between the individual capability to handle expected and unexpected external perturbations.

It is well established that elite and sub-elite soccer include a high number of sudden loadings of the upper body (shoulder tackles, turns, dribbles, headings, stops, and throw-ins) (2,12). These upper trunk loadings seem to be comparable to the "readiness training" performed in our previous study (17). Thus, soccer training may have a training effect on the reaction to SL including a potential to reduce the risk of low back injuries. However, the frequency of SL during recreational soccer among women is still unknown.

We investigated the effect of 16 weeks of "recreational soccer training" on the reaction to sudden unexpected trunk loading among untrained healthy women. This study was part of a large study on the health effects of recreational soccer training compared with running training among untrained women. We hypothesized that (a) recreational soccer training among women includes a high number of sudden loadings of the upper body and (b) recreational soccer training would significantly decrease the stopping time and the distance moved as a reaction to unexpected SL in the soccer group compared with the changes in the running and control groups.

Methods

Experimental Approach to the Problem

Sudden trunk loading demands a quick reflex response to stabilize the spine and prevent spinal buckling and injuries (18). The application of multiple SLs during soccer training was supposed to have a training effect on the reflex response to sudden unexpected trunk loading. This study therefore measured the effect of recreational soccer training on stopping time and distance moved as a reaction to sudden unexpected trunk loading. The SL was applied to the subject by a special setup (Figure 1). The effect of soccer training was compared with the effect of running training or no training (control group).

Subjects

Forty-six healthy, untrained, Danish women aged 19–45 years with a body mass, body mass index ($kg \cdot m^2$), fat percentage, and maximal oxygen uptake ($\dot{V}O_2max$) of 68.6 (*SEM* 1.6) kg, 24.1 (0.6), 33.4 (1.1)%, and 34.6 (1.1) $ml \cdot min^{-1} \cdot kg^{-1}$, respectively, took part in the study. The participants were nonsmokers, did not take medication, and had not been involved in any type of physical training for at least 2 years. The study was approved by the local ethical committee of Copenhagen (14606; H-C-2007-0012).

Procedures

The subjects were randomly allocated into a soccer group (SO, $n = 19$) and a running group (RU, $n = 17$). In addition, an untrained control group (CON, $n = 10$) was recruited. The participants in SO and RU carried out for 1 hour twice a week for 16 weeks, with similar mean heart rates during training (165 and 164 beats min^{-1}, respectively), whereas the participants in CON continued their daily life activities during the period. No group differences were present in preintervention values for age, body mass, fat percentage, or $\dot{V}O_2max$.

Training Intervention. The soccer and running training was performed outdoor, and the participants in SO could choose between 3 weekly soccer training sessions, whereas the participants in RU could choose between 4 running sessions. There was at least 1 day of rest between each training session. The soccer sessions consisted of ordinary 5-a-side, 7-a-side or 9-a-side matches on a 30–40 m × 45–60 m natural grass pitch, and the running sessions consisted of continuous moderate-intensity running at the same average intensity as the soccer group (82% of individuals' maximal heart rate). Each training session was initiated by a 5-minute low-intensity warm-up period. As the running group had problems coping with 1 hour of continuous running, both groups had their training sessions split in 3–4 segments over the first 6 weeks. The total number of training sessions was 28.8 (1.8 per week) and 29.5 (1.9 per week) for the participants in SO and RU, respectively.

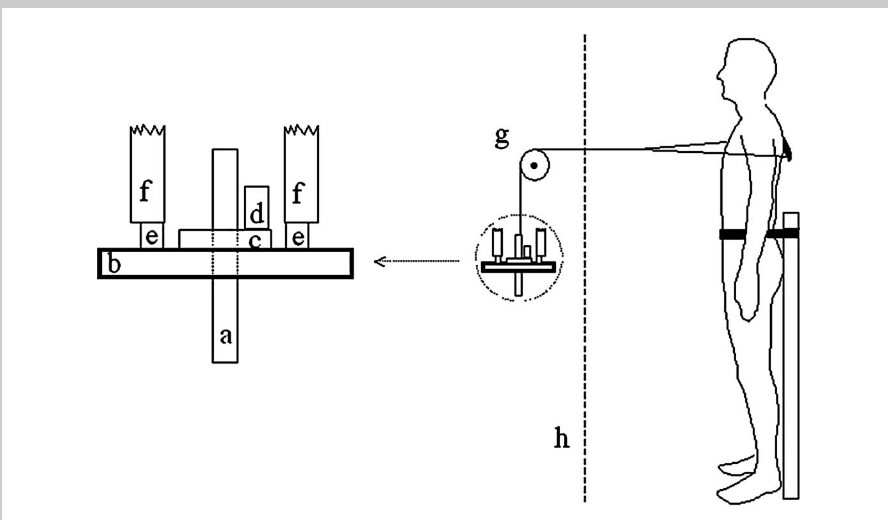

Figure 1. Setup for generating a sudden forward pull to the upper part of the subject's trunk. The wire is fastened to a rigid bar at the back by means of a harness attached to the upper part of the trunk. The movement of the trunk is measured by a potentiometer mounted on a reel. Details of loading device: a, cylinder; b, load; c, gripping device; d, solenoid for activating gripping device; e, holding magnets; f, load-bearing construction; g, reel with potentiometer; and h, visual shield. Generation of the sudden loading: First, the computer activates the solenoid (d) causing the gripping device (c) to fix the load (b) to the cylinder (a) and second deactivates the holding magnets (e). This releases the load (b) causing the weight of the load applied to the wire to be suddenly increased from 0.5 kg (a) to 5.9 kg (a–d). Modified after Skotte et al. (20).

Measuring and Test Procedures. Test of reactions to sudden unexpected trunk loading was performed before and after the training period. Group assignment was blinded to the test personnel. In addition, time-motion analysis of soccer training was performed for 9 subjects.

The method used for SL has been described in detail by Skotte et al. (20). Briefly, the setup for creating the SL was constructed as a load (58 N) that could be momentarily attached to a wire (Figure 1). The wire was connected to a reel, hereby transmitting the gravitational force of the load as a horizontal force applied to the trunk. The movement of the trunk was measured by a potentiometer mounted on the reel. The subject was fixed at the hip to obtain isolated trunk movements and to avoid any changes related to maintenance of postural stability. The position of the subjects at the first trial was recorded by color codes on the wire. In subsequent trials, the exact body position and applied moment were replicated by placing the reel in the same height and adjusting the body until a complete color match was obtained. The setup was controlled by a computer, which triggered the SL with a random delay between 10 and 30 seconds unknown to both the subject and the investigator. The subjects were asked to stand as relaxed as possible and were informed that they would experience a sudden moderate pulling forward, which they were asked to resist in order to maintaining their posture. Each subject was exposed to a set of 11 unexpected trials with a random delay between 10 and 30 seconds after informing the subject. The trunk movement and stopping time of the trunk movement were analyzed automatically: The maximum of the curve representing the trunk movement was detected, and the point in time corresponding to 95% of this distance was registered. The 95% level was chosen to describe the position of the peak of the trunk position curve because the peak itself was not clearly defined in a few trials.

Movement Patterns. Nine players were filmed individually close-up during 3 training sessions. Each player was filmed once. The video cameras (DCR-HC45E; Sony, Tokyo, Japan) were positioned at the side of the pitch at a height of about 8 m and at a distance of 10–15 m from the touchline. Subsequently, the videotapes were replayed on a monitor for computerized coding of the activity pattern. Numbers of non-timed activities (dive, jump, shot, pass, tackle [shoulder], tackle [foot], turn [0–90°, 91–180°, 181–270°, 271–360° from sideways, backward, or forward running], dribbles, stops, heading, and throw-in) were registered for each player during the entire training session. To be able to group data from the different training sessions, the activity pattern during 1 hour was calculated.

Statistical Analyses

Previous studies have shown that the first trial in a series of sudden loading events may differ considerably from the rest, indicating an acute learning effect (habituation) during repeated trials (20). Therefore, the first trial was excluded in the analyses of the SL, and the mean of trials 2–11 was used for analyses of the effect of the intervention.

The effect of training on stopping time and distance moved before stopping after a sudden unexpected trunk loading was analyzed by a mixed model analysis of variance (ANOVA) with subjects as random factor, nested by group (SO, RU, and CON), and time as fixed factor. A significant interaction effect between group and time was evaluated as an intervention effect. To increase power, ANOVAs were also performed with RU and CON as one collapsed group compared with SO. SPSS statistics 17.0 (www.spss.com) was used for all tests. Results are presented as mean (*SD*) unless otherwise indicated. The significance level was set to $p \leq 0.05$.

Results

Movement Patterns

The number of occurrences of specific activities including sudden loading of the upper body is presented in Table 1. During 1 hour of the training, the total of specific activities were 192 (63) corresponding to 3.2 (0.3) specific activities per minute. The total number of stops, turns, tackles, and shots was 28 (11), 66 (36), 37 (7), and 23 (12), respectively (Table 1).

Sudden Trunk Loading

The results of the sudden unexpected trunk loading tests before and after the training intervention are shown in Figures 2 and 3. The stopping time decreased ($p < 0.05$) in SO by 0.039 seconds corresponding to 14.5%, whereas no significant change was observed for RU or CON not significant (Figure 2). The change in stopping time in SO was different ($p < 0.05$) from the changes in the combined group of RU + CON.

The distance moved after sudden unexpected trunk loading decreased ($p < 0.05$) in SO by 1.2 cm corresponding to 23.7% (Figure 3), but no changes were observed in RU or CON (not significant). For distance moved, there was a significant interaction between groups (SO vs. RU and CON).

Table 1. Specific movements during a 1-hour football training session for untrained women ($n = 9$).

Activity	Mean ± *SD*
Diving	0.6 ± 1.1
Dribble	17.4 ± 11.1
Heading	0.2 ± 0.5
Jump	1.1 ± 1.9
Pass	17.4 ± 7.6
Shot	22.5 ± 12.4
Stops	28.2 ± 11.2
Tackle (shoulder)	21.1 ± 6.8
Tackle (foot)	16.2 ± 7.5
Throw	1.2 ± 1.5
Total turns	65.5 ± 36.2
Turns 0–90°	34.8 ± 15.7
Turns 91–180°	25.5 ± 18.6
Turns 181–270°	4.8 ± 3.6
Turns 271–360°	0.4 ± 0.7
Total	191.5 ± 63.3

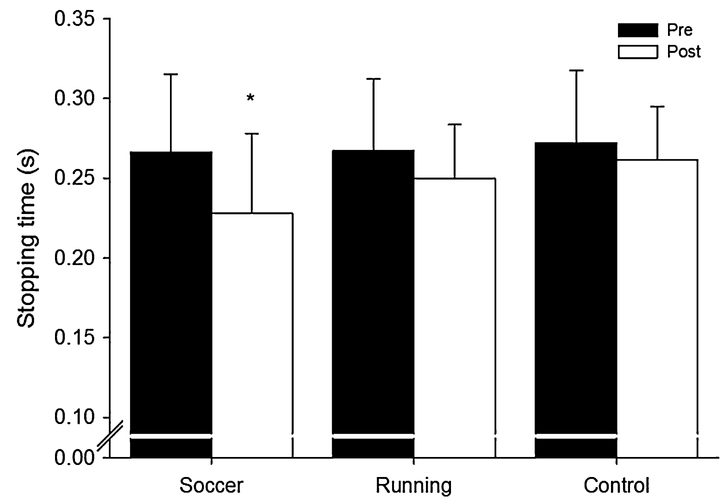

Figure 2. Stopping time of the trunk movement after sudden unexpected trunk loading before and after the training intervention in SO ($n = 19$), RU ($n = 17$), and CON ($n = 10$). *Significant reduction in stopping time compared with changes in the combined group of RU + CON (mixed model ANOVA, $p = 0.04$). ANOVA = analysis of variance.

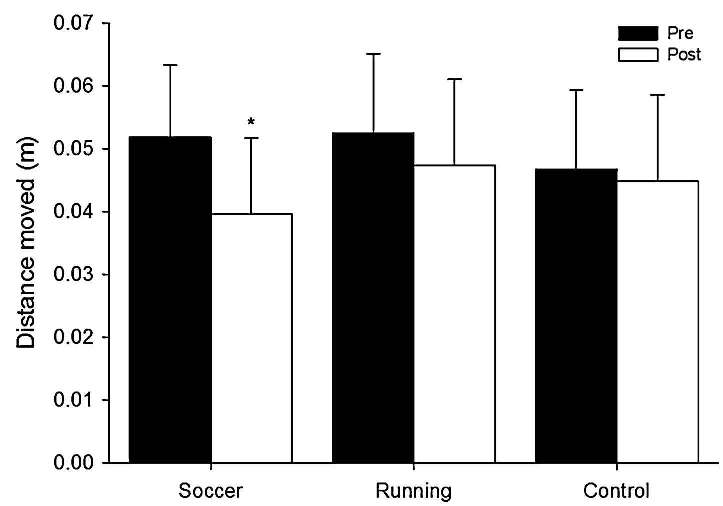

Figure 3. Distance of the trunk movement after sudden unexpected trunk loading before and after the training intervention in SO ($n = 19$), RU ($n = 17$), and CON ($n = 10$). *Significant reduction in distance moved compared with changes in the combined group of RU + CON (mixed model ANOVA, $p = 0.015$) and significant interaction between groups (SO, RU, and CON; mixed model ANOVA, $p = 0.04$). ANOVA = analysis of variance.

Discussion

Both hypotheses were confirmed: Recreational soccer among women included a high number of sudden loadings of the upper body. Also, recreational soccer training significantly decreased the reaction time and the distance moved as a reaction to sudden unexpected trunk loading in the soccer group compared with the changes in the running and control groups.

Movement patterns in soccer have been extensively studied (4,8,12), but studies have focused on elite athletes. The present study showed that untrained women playing recreational soccer have a significant number of actions causing sudden change in the load on the upper body. Each minute ~3 of these non-timed activities was performed. In addition, changes in the pace occur as often as every fourth second approximately (data not shown), which is similar to what has been observed in recreational male soccer (7). These frequent random changes in the activity pattern make soccer training potential as a training regimen to improve the reaction and coordination in the trunk.

The within-group changes for stopping time and distance moved (14–23%) were comparable to the changes (13–18%) observed in our previous study among health care workers (17). Interestingly, soccer training had similar effects as specific "readiness" training aiming at improving the reaction to SL (16,17). The individual data show that 85% of the individuals in SO decreased distance moved compared with 65% in RU, thus underlining the effect of the soccer training. Reduced stopping time and a shorter distance moved before stopping are considered to reduce the individual risk of low back injuries by decreasing the amount of energy accumulated before the slowing down of a forward movement of the trunk (15). In addition, a faster reaction implies an earlier stabilization of the spine (16). In the study of Cholewicki et al. (5), odds of low back incidence within the following 2 years increased 2% for every millisecond delay in reaction time. On this background, a decrease of 39 milliseconds in reaction time as observed in

SO is expected to have a considerable preventive effect on the occurrence of sudden low back pain (LBP).

We have previously shown (16,17) that training-induced improvements in the mechanical response characteristics to sudden unexpected trunk loading were associated with a change in the time distribution of the electromyographic (EMG) signal, characterized by an increase in the early parts of the response (up to 225 milliseconds) and a subsequent decrease. In contrast to the changes observed in patients with low back injuries (11,22), the EMG latency was unaffected by training, indicating that at least in healthy individuals the improved reaction to sudden loading is due to improvements in long latency reflexes or preprogrammed responses rather than a faster simple reflex response. In our previous studies (11,22), there were no changes in strength characteristics for back flexion or extension. The improvement in the reaction to SL was therefore considered to be due to change in coordination. Strength in back flexion or back extension was not measured in the present study, so it cannot be ruled out that recreational soccer training caused changes in back strength. However, it is evident that during recreational soccer for untrained men (4,9) and women (present study), the balance is markedly improved as determined by the one-legged Flamingo balance tests. The changes in reaction to SL in the present study may similarly be due to changes in coordination. The results from our previous study (17) showed a high sustainability of the training effect on the reaction to unexpected SL and seem to indicate that improvement in motor skills is based on long-lasting adaptations in the motor control systems. In line with this study, Tsao and Hodges (21) investigated long-term effects of training on postural control showing that changes were retained at 6-month follow-up ($p < 0.05$). The plasticity in motor control and motor systems of the spinal cord and cortex has previously been demonstrated in well-trained athletes (13) and professional dancers (14). In addition, training-induced changes in the preprogrammed responses or late components of the stretch reflex have been documented (10).

Physical exercise is recommended in the prevention of LBP (3), but there is insufficient evidence to recommend for or against any specific kind of exercise (3). Significant effects have been demonstrated for strengthening back extensors and flexors, increasing flexibility, and improving cardiovascular fitness (3). However, the sustainability of the training effect for flexibility, strength, and cardiovascular endurance is low (1) and calls for lifelong training. Coordination training on the contrary has a lasting motor learning effect (19) as also shown in the study among health care workers (17). It is therefore preferable also to promote coordination training in order to obtain a long-lasting effect. Especially, this applies if the subjects are not supposed to continue the training after an intervention period. Soccer therefore seems preferable compared with running, at least for improving the reaction to SL. Further studies focusing on LBP prevalence and injuries are needed because there may well be a low back injury preventing potential in soccer training for various groups of players.

In summary, recreational soccer among women included a high number of sudden loadings of the upper body and significantly improved the reaction to sudden unexpected trunk loading. Thus, participation in recreational soccer training seems to have the potential of reducing the risk of low back injuries among untrained women. Further studies are needed to confirm this.

Practical Applications

Soccer training among untrained women as opposed to running is effective in improving the reflex response to sudden unexpected trunk loading, suggesting that soccer training has a potential to reduce the risk of low back injuries. For several reasons, soccer can be recommended in general health promotion. First, many women and men consider soccer training a joyful and motivating team sport, which improves the compliance. Second, the health effects of soccer training seem to be independent of skills and prior experience with the sport and largely independent of the number of players who participate, thereby making soccer training interventions easy to organize. Third, the present study and several other recent studies provide evidence that soccer training has positive effects on cardiovascular, metabolic, and musculoskeletal fitness, including improved muscle function, balance, spine stability, and reaction to sudden loadings.

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