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The effects of short-term ski trainings on dynamic balance performance and vertical jump in adolescents

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Skiing is a sport where balance and strength are critical and which can be practiced actively especially from early years to old age. The purpose of this study is to examine the effect of a 5-day training of skiing skills on dynamic balance performance and development of vertical jump strength in adolescents. Sixteen adolescent volunteers who do not regularly exercise enrolled in the study (age 13.8±.5 years, height 160±8.5 cm, weight 56.6±10.9 kg and body mass index (BMI) 22±3.1 kg/m^2). The subjects participated in an intensive ski training program for 5 days for a total of 20 h (4 h of training and 2 h of free exercise). Their dynamic balance performance (on a Sport Expert MED-SP 300 balance platform) and vertical jump (strength) (New Test 2000) were measured before and after the training program. Our study shows that medial/lateral (M/L) balance improved after a 5-day ski training ($p<0.05$). However, no positive development was observed in postural balance in the anterior/posterior (A/P) plane. This study shows that repeating short-term trainings in sports branches such as skiing could have a more pronounced effect on the improvement of balance and strength.

Key words: Ski training, dynamic balance, postural control, vertical jump, adolescence.

INTRODUCTION

Skiing is a sport that can be practiced from childhood until advanced ages and requires balance control, weight transfer skills and particularly isometric muscle strength in the lower extremities. The integration of visual, kinesthetic and vestibular information is essential for balance skills (Vuillerme and Nougier, 2004; Paillard et al., 2006). The speed of acquiring skiing skills and the final level achieved therein are associated with balance. The development of skiing skills, muscle strength and adequate postural control depends on the ski training process (Muller and Schwameder, 2003; Kroll et al., 2010). Fransson et al. (2002) investigated the short-term and long-term effects of adaptation to posturography. Their results show that postural control gradually improved during the first five consecutive days of measurements and these improvements could be maintained in the following 3 months. Besides, participation in physical activity is associated with better academic or cognitive performance for children 11 to 13 years old. Budde et al. (2008) showed that acute bouts of coordinative exercises revealed an enhanced attention and concentration performance. Therefore, short-term intensive exercises or trainings could be expected to support the development of both physical and academic abilities in adolescents.

Postural control is the conscious stabilization of the body while standing and the automatic maintenance of balance by keeping the center of gravity over the base of support to prevent falls (Shaperd, 2000). In developing this motor skill, balance control depends on muscle strength (Perrin et al., 2002). Postural stability varies with the requirements of the sports branch. For skiers not to

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Table 1. Anthropometric measurements of the ski training group.

	Age (year)	Height (cm)	Weight (kg)	BMI (kg/m^2)
N=16 M±SD	13.8±.5	160±8.5	56.6±10.9	22±3.1

M: mean; SD: standard deviation.

Table 2. Body mass and posture score of ski training group.

	Mass of body fat (%)	Lean body mass (kg)	New York posture score
M±SD	19.9±10.2	44.7±6.6	62±5.2

M: mean; S.D.: standard deviation.

fall while skiing, quasi-static equilibrium, sensory-motor balance and dynamic movements are critical (Fetz, 1997; Malliou et al., 2004).

Adolescence is the period when children acquire basic motor skills with the contribution of educational programs (Miller, 2006). Improving balance and strength particularly in this period supports the development of other motor skills (Gantiraga et al., 2006). Physical education teachers argue that short-term intensive ski trainings introduced especially for this age group as part of the curriculum during the academic year would increase postural control and could contribute to balance and the strengthening of lower extremities in particular. As ski resorts are usually not close to residential areas, students can only ski during their winter breaks so as not to interrupt their schooling. In countries where winter sports can be performed for longer periods, such ski training programs are part of the annual curriculum of private schools. In adolescence, as a result of growth and physical development, balance parameters improve as well. Moreover, at advanced ages, balance becomes a motor skill that improves the quality of life.

According to studies conducted to assess sport-related postural balance, trainings incorporating proprioceptive components improve both performance and balance control (Perrin et al., 2002). Consequently, balance skills acquired in different sports branches will vary (Davlin, 2004; Perin et al., 2002; Bergmann et al., 2002). Neuromuscular training programs (multi-intervention programs with a combination of balance, strength, plyometric, agility, and sport-specific exercises) that include balance exercises are often with the aim of optimizing performance. The relation balance performance is equally complex. While instructors argue that balance and stabilization exercises are necessary to improve postural and neuromuscular control, some believe that multi-intervention programs are more beneficial (Zech et al., 2010). Moreover, it is not exactly clear whether sport-specific (such as ski trainings) or combined exercise programs are more effective in improving postural control. There are studies which show that balance development in skiing is more pronounced in the A/P plane. While gliding rapidly and in a controlled manner down a slope, the control of the center of gravity will be different from that in the normal posture. For a swift position change in skiing, the skill of keeping your whole body in balance and maintaining that balance are important. Balance is one of the most critical factors in sportive performance. Therefore, training programs that incorporate balance exercises starting in childhood will have a significant effect on physical development in adolescence. It is seen that balance improves with the number of years engaged in sports (Paillard et al., 2006).

The objectives of this study are to (1) examine the effect of training ski-specific technical skills on dynamic balance performance and vertical jump (strength) in adolescents, and (2) determine whether a short-term (5-day) intensive ski training program is sufficient to improve postural control.

MATERIALS AND METHODS

Participants

Sixteen adolescent volunteers without any visual-sensory disorders were enrolled in the study. The subjects did not have any injuries to their lower extremities in the last year and did not exercise regularly. In order to form a homogenous group, a posture analysis was carried out before the trainings and adolescents with especially no spinal or other postural problems were recruited. Their postural changes were monitored by way of the New York posture analysis method and no postural disorders were identified. Similarly, body mass index (BMI) and body fat measurements were made before the trainings and adolescents with comparable features were included in the study.

The anthropometric measurements of the subjects are presented in Table 1. They gave their informed consent to the experimental procedure as required by the 1964 Declaration of Helsinki of the World Medical Organization (WMO) (1996). The study was approved by the local ethical committee of the Marmara University.

Procedures

Before the ski trainings, the weight, height and skinfold thickness of the study group were measured and a postural analysis was made (Table 2). The New York posture analysis method was used to analyze the posture, and using this assessment system, possible postural changes at 13 different points of the body were monitored

Table 3. Comparison of dynamic balance and vertical jump tests.

	Pre-ski training (M±SD)	Post-ski training (M±SD)	p
Dynamic balance (M/L) (Degree)	6.8±1.4	5.6±1.6	.023*
Dynamic balance (A/P) (Degree)	7.4±1.7	8.6±.9	.010*
Vertical jump (cm)	23.6±5.1	24.5±6.1	.119
Right foot vertical jump (cm)	12.4±4.1	13.5±5.3	.243
Left foot vertical jump (cm)	11.9±4.1	12.4±4	.339

M: mean; S.D.: standard deviation, M/L: Medial/Lateral, A/P: Anterior/Posterior.
* Indicates differences ($p < 0.05$) between pre-ski training and post-ski training groups at baseline.

and scored. The total score of the test could be maximum 65 points and minimum 13. A total score of ≥45 in the standard assessment criteria developed for this test was considered "very good" and 40 to 44 "good". The skinfold thickness measurements were made with a skinfold caliper (at the triceps and subscapula). Skinfold thickness measurements (Harpenden caliper) were carried out three times on each point in a rotation system. Slaughter equations were used to calculate body fat.

Adolescents who had not had any ski training before participated in a basic and intensive ski training program totaling 20 h in 5 days (4 h of training and 2 h of free exercise daily). The ski trainings were performed at Mt. Uludag (Bursa, Turkey). The ski training program was designed to develop basic skiing techniques.

The ski training included the following:

Day 1: introduction to and use of ski gear, walking, climbing and straight run;
Day 2: snowplough skiing and turns;
Day 3: kick turns and skiing across the slope;
Day 4: side slipping and simple turns, skiing pits and bumps; and
Day 5: skating, side hill turns and stem turns.

Their dynamic balance performance (on a Sport Expert MED-SP300 balance platform) and vertical jump (New Test 2000) were measured before and after the training program (Hoff et al., 2001). The dynamic balance parameter measured was the accumulated sway in the x and y directions. Vertical jump tests were used to indentify improvements in strength.

The study was carried out in a laboratory environment in the same slot of the day for all participants (10.00 to 13.00) when their body was rested, and necessary precautions were taken to avoid the impact of environmental factors (e.g. noise, temperature).

Statistical analysis

Descriptive statistics were used in the analysis of data gathered in the study, and a paired t-test was used for the differences between the pre-ski training and post-ski training values of the groups. The SPSS 14.0 program was preferred for the statistics. The significance level was set at $p<0.05$.

RESULTS

Dynamic balance (M/L, A/P) and vertical jump (both feet, right and left foot) values are given in Table 3. The difference observed between pre-ski training (6.8±1.4) and post-ski training (5.6±1.6) values of dynamic balance in the M/L plane was found to be statistically significant (p=.023). Improvement in dynamic balance was observed in the M/L plane, however, dynamic balance in the A/P plane was negatively affected by the ski training (pre-ski training: 7.4±1.7, post-ski training: 8.6±.9; p=.010).

Despite the fact that there was an increase (minimal) in vertical jump values due to the training, no statistically significant difference was found between pre-ski training and post-ski training values for vertical jump with two feet, right and left foot ($p>0.05$). These results indicate that 5-day ski trainings are not sufficient to increase strength significantly in lower extremities.

DISCUSSION

The study was designed to identify to what extent short-term ski trainings can improve dynamic balance performance and vertical jump in adolescents who do not exercise regularly.

The main finding of the study is that a one-week ski training improved dynamic balance in the M/L plane. However, in the A/P plane, there was deterioration compared to normal postural control.

At the beginning of basic ski training, the static contraction of legs is important for M/L balance and the braking of the slide. The authors suggest that the improvement in the M/L plane could be associated with this braking movement that helps to maintain balance and prevents falls in ski trainings. The fact that the abductor muscles in the lower extremities are more active isometrically could explain the improvement of balance in the M/L plane. Studies conducted in various branches with repeated specific trainings report that sports branch-specific trainings (for football, dancing, gymnastics, basketball, etc.) and specific balance exercises are effective in achieving postural control and dynamic balance in the M/L and A/P planes (Biec and Kuczyn, 2010; Aldemir et al., 2011; Bressel et al., 2007).

In this study, the development of balance in the A/P plane was contrary to expectations raised by studies on dynamic balance. The duration of trainings in the literature on skiing is at least 12 weeks; therefore, balance in the A/P plane did not improve and there might be negative feedback instead because of the short duration of the ski training. Researchers state that postural balance, particularly in the anterior-posterior

direction, improves in skiers who do long-term trainings (Feltz, 1997; Muller and Schwameder, 2003; Malliou et al., 2004). However, they observe that there is not any increase in the A/P plane in measurements made in specific skiing positions (Noe and Paillard, 2005). In their study, Olivier et al. (2008) state that children up to 12 years have a better postural control in the A/P plane as compared to the M/L plane. The A/P plane is controlled with the strength of ankle dorsiflexor/plantarflexor muscles. Our results carried out with adolescents, on the other hand, suggests that ankle dorsiflexor/plantarflexor muscles are not strengthened as desired in short-term trainings and that because of inadequate weight transfer skills, there is no significant increase in the A/P plane.

Falls tend to be more frequent as skills are being developed through the stages of the ski training because balance is deficient and the muscles in the lower extremities are weak. Especially in moves where the center of gravity is closer to the ground, balance and leg strength need to be high. According to pre-ski training and post-ski training values obtained in our study through measurements of vertical jump, for both the right and left foot, there is an increase in leg strength though not statistically significant, which suggests that these values could increase significantly should the training be extended. In a study carried out with elite athletes participating in a ski training for 6 days, identified that balance exercises during ski trainings increase dynamic balance performance and leg strength (Camliguney et al., 2012). Standing in balance (stability) and the strength of muscles in lower extremities are critical for movement control in skiing (Feltz, 1997; Muller and Schwameder, 2003).

Our secondary findings show that a short-term (5-day) intensive ski training program is not enough to ensure a positive development in postural control.

Because of its nature, skiing involves slope sliding; therefore, the center of gravity in postural balance is different when skiing. We believe that there was not enough time to acquire motor skills needed for better postural control as the ski training in our study lasted 5 days. As stated in some studies conducted to assess sportive postural balance, trainings help to acquire new balance control skills, which further improve with practice specific to various sports disciplines (Davlin, 2004; Perrin et al., 2002; Bressel et al., 2007). Whereas some studies report that training years have a positive effect on balance performance (Paillard and Noe, 2006; Paillard et al., 2006), others state that no such effect is evident (Paillard et al., 2002).

Research on skiing shows that because of the changes in speed while skiing, the friction of snow and the skis increase as a result of which the body's position changes in order to maintain balance (Feltz, 1997; Muller and Schwameder, 2003; Malliou et al., 2004). In their study, Müller et al. (2011) state that a ski-specific balance test would produce more objective results. While skiing, the position of the body changes depending on various accelerations, different terrain types and the ever-changing forces of friction between the skis and the snow. Therefore, postural control during skiing is different from normal postural control. Peterson et al. (2006) conducted a study where they measured the balance performances of children and adults, and found that subjects older than 11 years used somatosensory and visual information for postural control.

The limitation of our study is that the ski training program lasted 5 days. Research shows that the duration of training has an influence on balance control. We recommend that future studies be made with a group participating in an extended ski training.

Our study was designed with the belief that postural balance could be developed faster with ski trainings incorporated into the annual curriculum of physical education. The authors believe that a younger age group would limit their study and that adolescence is a period that can yield better results as somatosensory and visual information can be used for postural control.

Conclusion

The main finding of this study is that dynamic balance performance in the M/L plane improved with a 5-day ski training. However, there was no positive development in the postural balance in the A/P plane. This made the authors conclude that a 5-day ski training was not sufficient and that longer training programs would be more instrumental in improving postural balance.

There was an improvement in vertical jump though not statistically significant because of the short duration of the ski training and the extra weight of the skiing equipment.

Maintaining the center of gravity over the base of support of the body is essential for the stabilization of balance. The rapid shifts of the center of gravity during skiing make it more challenging to keep the center of gravity over the base of support. Since the duration of the training was short, skiing skills could not improve sufficiently. The authors believe that this is the reason for the negative development in dynamic balance performance in the A/P plane. According to the literature, dynamic balance performance in the A/P plane can improve if proprioceptive trainings are continued.

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