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Comparison of Standard and Newer Balance Tests in Recreational Alpine Skiers and Ski Novices

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ABSTRACT Alpine skiers should physically prepare for skiing due to the specific body movements it requires. As balance is essential for the success of competitive alpine skiers, we investigated its importance during preparation for alpine skiing in recreational skiers. We included 24 male participants; twelve recreational skiers just after 10 days of alpine skiing, and twelve alpine ski novices. All participants were tested with two balance tests (BAL40 and GYKO). Participants of the two groups did not differ significantly in the results of the BAL40 standard balance test. In contrast, we found significant differences in four out of six variables measured with the GYKO test performed on BOSU trainer during the two-feet stand. Participants specifically differed in the variables overall average body tilt (p=0.02), overall average deviation of body tilt (p=0.00), overall medio-lateral average body tilt (p=0.01), and overall medio-lateral average deviation of body tilt (0.00). Average results were lower for participants of the group of recreational skiers than for participants of the novice alpine ski group, suggesting that balance is important for recreational skiers, either as an acquired trait during skiing, or the result of conditioning training in the preparation period for skiing. According to the results, we would advise recreational skiers as well as people planning to be involved in alpine skiing as a new recreational activity to include balance exercises in the preparation period.

KEY WORDS Recreational Level Alpine Skiers, Motor Abilities, Conditioning Training.

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Introduction

Due to specific movements, alpine skiing imposes high requirements concerning physical fitness, particularly regarding muscle strength and balance abilities (Ferguson, 2010). It is a sport with predominant eccentric muscle contraction (Berg & Eiken, 1999; Hoppeler & Vogt, 2009), which is specific muscle activity for slowing down in every-day life, for example, while walking downhill. Hoppeler and Vogt (2009) investigated the concept of eccentric-contraction-based conditioning training in professional alpine skiers. In that study, a bicycle ergometer specially designed to produce eccentric movements was used for the training of junior alpine ski competitors. The study showed that the dosing of eccentric contractions has a beneficial effect on maximal speed during a competitive race in alpine skiing. In line with this, it is generally accepted that competitive level skiers develop and train those abilities, which are crucial for success in specific disciplines of alpine skiing.

In contrast, alpine skiing is also one of the most popular winter leisure activities, with millions of people participating at the recreational level. The popularity has become even more apparent since the introduction of carving skis with more sidecut, and these changes have resulted in greater requirements of physical fitness including a sense of balance from recreational skiers (Müller & Schwameder, 2003; Cigrovski, Božić, Prlenda, 2012; Rachner et al., 2012). Many studies have shown that the development of specific motor abilities and muscle strength has a beneficial effect on the safe and effective learning of alpine skiing (Hébert-Losier & Holmberg,

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2013). As preparation for alpine skiing can be time-consuming (usually should start few months before actual skiing), people often choose not to engage in training. To increase an individual's skiing performance and reduce the skiing injuries, greater attention should be paid to the fitness level (Turnbull et al., 2009; Raschner et al., 2012) and physical preparedness for alpine skiing. Therefore, the idea is to offer recreational skiers specialized and directed programs of shorter duration targeting muscles involved in alpine skiing, instead of the gym, running or bicycling. In the preparation period for recreational alpine skiing, depending on the person's lifestyle, exercises for eccentric muscle contraction should be included.

In addition, it is also prudent to include exercises for balance, which is key for maintaining stable positions on skis (Wojtyczek, Pasławska, Raschner, 2014), although, interestingly, literature on balance parameters during skiing is rare (Hebert-Losier et al., 2014). Specifically, one of the prerequisites for optimal ski turn is maintaining central balance position on skies throughout all turn phases (Loland, 2009); of secondary importance is the positioning of the skies on the side edges and leading the skies in desired direction. If this is not fulfilled, skies will probably skid, and the skier will lose control over the speed of skiing and the central balance position (Spörri et al. 2012; Cigrovski & Matković, 2015). Hrysomallis (2007) reported poor balance skills were significantly associated with an increased risk of injuries, but Staniszewski and colleagues (2016) showed that skiing has a positive effect on postural stability regardless of the skier's level of technical skills. There are many tests to evaluate balance, but not all are sufficiently discriminative to identify people with low performance and facilitate intervention programs to develop/improve specific balance skills for alpine skiing. Moreover, there is still insufficient evidence from controlled trials on the relationship between laboratory balance tests, field balance tests, and the acquisition of alpine ski knowledge/skiing performance. Therefore, the purpose of the present study was to evaluate the balance performance on two balance tests-standard balance board test BAL40 and newer GYKO test in order to find the best one to evaluate balance performance of skiers and non-skiers in order to help improve balance during preparation for skiing.

Methods

Participants

We included 24 participants, all male students of the School of Kinesiology, University of Zagreb. Their average age was 23.8±1.78 years. Participants were divided into two different groups; one group included recreational skiers, who participated in alpine skiing for at least 10 days per year, and other group included participants that had never been involved in alpine skiing (alpine ski novice). This grouping was done according to participants' self-evaluation. Participants were preselected according to their motor abilities during the selection process of enrolment to the School of Kinesiology and did not differ significantly in general motor abilities, i.e. they were a homogenous group according to motor abilities. This study was approved by Ethics Committee of the School of Kinesiology, University of Zagreb. Each participant voluntarily provided written informed consent before participating and was thoroughly informed about study aims and procedures.

Variables

All included participants were tested on two different balance tests assessing balance. The newly selected test for the evaluation of balance was performed on a BOSU balance trainer with a GYKO instrument attached to participants' backs (GYKO test), while a standard test evaluating balance (BAL40) was performed on a balance board during two-feet jumps. Tests were performed during the 2015 winter season after recreational skiers

FIGURE 1 Participant during GYKO testing at BOSU balance trainer

had completed 10 days of alpine skiing. For all participants, tests were conducted in the same measurement conditions and at the same time of day.

The GYKO test is performed on a BOSU balance trainer, which simulates the unstable conditions encountered during alpine skiing. The participant is asked to stand barefoot for 30 seconds in the central balance position on a BOSU balance trainer with a GYKO instrument attached to the thoracic part of the back. The GYKO is a specifically designed measurement tool for the analysis of movement, with a Bluetooth data transmission option providing real-time measurement data transfer to a PC via the Microgate software which is a validated program for data processing and interpretation. GYKO makes it possible to objectively evaluate and monitor the stability and balance of a standing subject. It provides information on various components of the postural system, such as visual, proprioceptive, labyrinthine, etc., through indexes such as sway frequency, projection travel speed, and projection length area. In this research, we specifically measured the following: overall average body tilt (Length), overall average deviation of body tilt (Mean length dev), overall medio-lateral average body tilt (Ml length), overall medio-lateral average deviation of body tilt (Ml length dev), overall antero-posterior average body tilt (Ap length), overall antero-posterior average deviation of body tilt (Ap length dev). Measurements were done in mm.

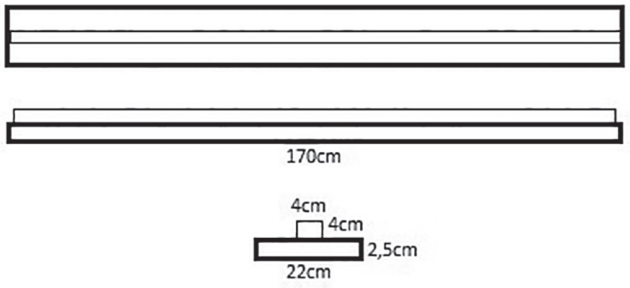

FIGURE 2 Construction characteristics of instrument for BAL40 test

The BAL40 test is performed on a measuring instrument 170.0 cm in length and 22.0 cm high. The height of the basic edge was 2.5 cm, with the height and width of the elevation being 4 cm. The upper elevation was marked with a line which divided it into two equal parts. Participants placed both feet on the elevation on one side of the line. Then they arbitrarily performed two-feet jumps while skipping over the marked line that divided the elevation into two symmetrical parts. Participants had to perform as many correct two-feet jumps as possible. The total number of performed two feet jumps was recorded and the task was repeated three times. The final result represented the best achieved result. An attempt was considered to be invalid if the participant touched the lower surface of the measuring instrument or the line in the middle of the measuring instrument with any part of the foot during test performance.

Statistical Analysis

Data was processed with Statistica statistical program (ver.12). Basic descriptive parameters were calculated for tests evaluating balance. Differences between participants of the two groups (group one (recreational alpine skiers) and group two (alpine ski novice participants)) in the results of tests assessing balance were detected by t-test. Results were significant at $p<0.05$.

Results

In Tables 1 and 2, basic descriptive parameters are given for two groups of participants in the BAL40 test and six variables obtained in the GYKO test.

TABLE 1 Basic Descriptive Parameters of BAL40 and GYKO Test Results for Alpine Ski Naive Participants (n=12)

Variable	M	Min	Max	SD
Bal40	3.96	2.33	5.00	0.82
Gyko-length	222.41	121.1	319.10	67.30
Gyko- mean length dev	2.94	1.87	4.53	0.86
Gyko-ml length	139.09	61.37	192.73	43.86
Gyko-ml length dev	16.00	9.93	24.53	4.99
Gyko-ap length	141.62	79.87	222.53	49.18
Gyko-ap length dev	4.31	1.55	8.70	2.21

Legend: Bal40 – balance evaluation test; Gyko-length – overall average body tilt on BOSU trainer during two-feet stand; Gyko-mean length dev – overall average deviation of body tilt on BOSU trainer during two-feet stand; Gyko-ml length – overall medio-lateral average body tilt on BOSU trainer during two-feet stand; Gyko-ml length dev – overall medio-lateral average deviation of body tilt on BOSU trainer during two-feet stand; Gyko-ap length – overall antero-posterior average body tilt on BOSU trainer during two-feet stand; Gyko-ap length dev – overall antero-posterior average deviation of body tilt on BOSU trainer during two-feet stand

In an additional analysis, a t-test was used to determine differences in balance between the two groups of participants.

TABLE 2 Basic Descriptive Parameters of BAL40 and GYKO Test Results for Recreational Alpine Skiers (n=12)

Variable	M	Min	Max	SD
Bal40	3.86	3.33	4.66	0.48
Gyko-length	163.77	125.33	244.87	34.67
Gyko- mean length dev	1.94	1.17	2.90	0.55
Gyko-ml length	97.05	73.27	140.90	22.65
Gyko-ml length dev	10.02	4.93	17.53	4.34
Gyko-ap length	110.22	86.1	168.97	24.80
Gyko-ap length dev	2.71	1.43	5.83	1.27

The study did not show any significant differences related to the BAL40 test between recreational skiers and novice alpine ski participants (Table 3). In contrast, analysis of results in the GYKO test shows statistically significant differences between the participants pertaining to the group of recreational alpine skiers compared to the group of novice alpine ski participants in four variables. Recreational alpine skiers differed from novice alpine ski participants in results in overall average body tilt (p=0.02), overall average deviation of body tilt (p=0.00), overall medio-lateral average body tilt (p=0.01), overall medio-lateral average deviation of body tilt (0.00). After 10 days of alpine skiing, recreational skiers had fewer deviations and body tilts when measured with the GYKO on an unstable surface such as BOSU balance trainer, indicating a higher level of balance.

TABLE 3 T-test Results for Alpine Ski Naive Participants (0) and Recreational Skiers (1)

Variable	M	M	SD	SD	t	p
Skiers=1; Alpine ski naïve participants=0	0	1	0	1		
Bal40	3.96	3.862	0.82	0.47	0.36	0.74
Gyko-length	222.41	163.74	67.30	34.67	2.45	0.02*
Gyko- mean length dev	2.94	1.93	0.86	0.55	3.10	0.00*
Gyko-ml length	139.09	97.05	43.86	22.65	2.69	0.01*
Gyko-ml length dev	16.00	10.02	4.99	4.34	2.86	0.01*
Gyko-ap length	141.62	110.22	49.18	24.80	1.80	0.09
Gyko-ap length dev	4.31	2.71	2.21	1.27	1.98	0.06

Legend: * p<0.05

Discussion

Among competitive skiers physical training is mainly directed to the improvement of performance, while in recreational alpine skiers it is intended to prevent injury and improve the learning of alpine ski basics, making it safe and enjoyable. Moreover, while competitive skiers invest significant amounts of time for physical training, recreational skiers often find it time consuming and avoid partaking in physical preparation training Several prominent orthopedic authorities have advocated conditioning to reduce the risk of skiing injuries (Senner et al., 2009), but there is still no solid data indicating which program and what exercises would be of importance. It seems prudent to include exercises involving the muscles and joints that do the workload during alpine skiing, and specifically train/improve motor abilities such as lower body strength, power and balance (Cigrovski, Prlenda, Radman, 2014; LeMaster, 2009).

The investigation of young students of physical education showed that motor abilities correlate with the success of acquiring ski knowledge, especially during beginning phases (Aerenhouts et al., 2013). Moreover, better prepared recreational alpine skiers will have lower injury risk during learning and improving ski technique. Balance is a major component of performance in skiing, and different studies confirmed that loss of balance was the main reason for sustaining a skiing injury (Laskowski, 1997; Natri et al., 1999). In contrast, studies suggest that level of expertise in alpine skiing correlates with balance and that skiing can improve one's balance abilities (Wojtyczek et al., 2014). An investigation by Staniszewski and colleagues (2016) showed that training program affects forward/backward and sideways body sways in ski beginners, which works in a positive way for the function of maintaining balance in skiing. In line with this, our investigation aimed to determine the importance of motor ability balance for recreational alpine skiing as well as the value of different tests used for balance assessment.

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The investigation of postural control performed by Noe and Paillard (2005) on competitive level alpine skiers (national and regional level competitors) showed its importance in ankle injury prevention. Professional skiers obtained significantly better balance values while wearing ski boots, suggesting the ski-specific impact on balancing habits (Noe and Paillard, 2005). Moreover, Mildner, Lembert, and Raschner (2010) suggest that in addition to general conditioning, skiers should utilize general and ski-specific balance and sensomotor training, which could help in knee injury prevention.

We used tests to evaluate both static and dynamic balance in young capable male students of the School of Kinesiology, divided into two groups differing mainly in their involvement in recreational level alpine skiing. One group included recreational alpine skiers after 10 days of an alpine ski program, and the other group included alpine ski novices, with no experience in alpine skiing. Due to the importance of balance and achieving and maintaining a stable position on skis (Noe et al., 2009), we attempted to define specific exercises that can influence better preparedness for alpine skiing at the recreational level. As there are over 200 million people worldwide practicing recreational skiing, it is important to find specific exercises that would aid in injury prevention (Hunter, 1999). Programs that are usually offered to people are comprehensive and last a few months (Thiel et al., 2009). Their main flaw is that only a small number of people participate and continue this practicies. In the case of non-adherence, recreational alpine skiers regardless of the improvements in equipment for alpine skiing risk the possibility of injury (Cigrovski & Matković, 2015). Modern ski carving techniques require a strong sense of balance while edging with skies.

Moreover, stiff ski boots increase the difficulty of balancing (Mildner, Lembert, and Raschner, 2010). Those are the reasons that current trends in conditioning training lead to intensive programs with efforts to detect people with lower level of specific motor abilities that will improve them and thus prevent injuries, which are otherwise inevitable (Burtscher et al., 2009; Senner et al., 2009). According to research, more than 90% of all injuries are due to falling, i.e. losing balance, and can to a great extent be prevented by adequate physical preparedness (Burtscher et al., 2009; Tchórzewski et al., 2013; Philippe et al., 2014).

Interestingly, publications on issues related to balance parameters during skiing are relatively rare in alpine ski literature (Hebert-Losier et al., 2014). Available data suggest different tests to evaluate balance; some more useful than others from the aspect of testing practicality in recreational skiers (Ružić et al., 2008). For competitive skiers, Nourrit and coworkers (2003) suggest the use of specific ski-stimulators which help to develop dynamic balance and at the same time use muscle contractions characteristic for alpine skiing. In our previous research, we tested the usefulness of different laboratory balance tests and found a correlation between levels of balance recorded on plywood balance board with newly acquired ski knowledge in ski beginners. Our results suggest that participants doing better on balance tests achieve better results in learning alpine ski technique and vice versa (Cigrovski et al., 2009). Similarly, Ružić and colleagues tested the power of balance board as a surrogate test for "on-the-skis" balance (Ružić et al., 2008). Available balance tests differ greatly not just in their commercial availability but also in a safe and easy way of testing. These were the main reasons why in this study we used specific balance tests in the context of recreational level alpine skiers. The BOSU balance trainer is a useful tool for evaluating balance. It is easily accessible and very usable for mimicking conditions of "on-the-skis" balance. GYKO, in contrast, represents the tool to measure and objectify the balance skill of a subject. When attached to the trunk it provides information about the body sway of the subject and it enables evaluating the relative contribution made by the various components of the postural system by giving information on projection length and area, projection travel speed, and sway frequency. GYKO is mainly used as a helping tool monitoring success of physical therapy after injury or orthopedic operation, and to the best of our knowledge there are no literature data on its use in testing the balance of recreational alpine skiers, so in this sense our data pioneers its use in monitoring present balance skills before skiing or the development of specific balance skills after the alpine ski program.

Our research posits balance to be a major feature that needs to be incorporated in the conditioning training of people planning to participate in alpine skiing. According to our results, the balance was more pronounced in the group of recreational level skiers, perhaps as a result of specific muscle coordination and postural control exerted by alpine skiing. Similarly, a study by Zemkova (2014) showed that skiers were more stable than non-skiers while standing in ski boots. Balance training on a BOSU trainer is advisable because it offers the possibility to train static balance i.e. maintaining a stable position on the unstable surface. Analysing our results, we would suggest trainers and alpine ski instructors to design the conditioning training of recreational level skiers in a specific and focused way. By using specific exercises on a BOSU trainer, they will mimic conditions and muscle work specific for alpine skiing, and directly influence the development of those motor abilities that are crucial for learning and perfecting/mastering alpine skiing. This should also help to minimize ski injuries and lead to effective ski learning.

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