A NEW RATIONALE TO ASSESS BALANCE IN SKIERS

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ABSTRACT

Balance control is crucial for performance enhancement and in this last decade, it has become a crucial target during coaching routines with unstable equilibrium conditions. The spread of multiple approaches to evaluate balance improved the knowledge of the posture and body arrangement during the performance, when the action is complex and rapid such as skiing. The aim of this study is to evaluate skiers' balance in an ecological condition (with boots) versus a traditional way (barefoot). Twenty adolescents practicing alpine skiing, who participated in national championships, took part in this comparative study. The athletes were invited to carry out a stabilometric test lasting 30 seconds in a rest condition. They randomly carried out the test without shoes (barefoot) and with their own ski boots (boots) on a balance platform. A period of 30 minutes elapsed between the tests conditions to minimise the learning effect. The comparison of ellipse area values between barefoot and boots condition showed high significant differences in boys ($p < 0.001$, $\eta^2 = 0.574$) and in girls ($p = 0.040$, $\eta^2 = 0.177$), while the length of the COP displacement or sway did not show significant differences. The assessment with boots is different than the usual setting, whereas the athletes performed the trial in a barefoot condition, suggesting a more functional approach to training because the final performance should be considered as a holistic interrelation between the athlete, shoes, tool, technique, condition, and environment.

Keywords: balance, professional skiers, skiing, ski boots, functional evaluation

INTRODUCTION

During the standing posture, the neuromuscular system continuously performs body arrangements to maintain a standing position with a low energy cost (Gribble et al., 2007). In fact, the upright posture involves both voluntary movements and postural reflexes able to compensate the slight oscillations of the whole body (Kwon et al., 2014). This process occurs through a combination of cutaneous and kinaesthetic mechanoreceptors incorporated in the skin surface, muscles and joints to provide inputs to the central nervous system (Gribble et al., 2007; Sforza, Eid, & Ferrario, 2000).

Currently, a valid method to measure postural control is the evaluation of the centre of pressure displacement (COP) (Baldini et al., 2013; Lin et al., 2008; Pagnacco et al., 2015; Ruhe et al., 2010; Taylor et al., 2015) that is the resultant of the ground reactions and of the external forces acting on the whole body (Winter, 1990). The trajectory of the COP has therefore, in the last 10 years, captured the interest of the scientific community because it is considered a robust estimate of the centre of mass movements during daily activities (Masani et al., 2014).

In fact, recently, the COP sway has also been used to evaluate static posture (Saripalle et al., 2014), asymmetry (Gasq et al., 2014), the effects of different natural or artificial corrected dental conditions (Amaral et al., 2013; Baldini et al., 2013; Perinetti et al., 2010, 2012), and the effects of rehabilitation sessions for the recovery of balance (Freyler et al., 2014). COP sway was also assessed to evaluate the general ability in motor control (i.e., balance) among different sports athletes (Asseman et al., 2008;

Chapman, et al., 2008; Sforza et al., 2003) and after muscle fatigue (Bruniera et al., 2013).

From another point of view, balance control is crucial for performance enhancement (Latash, 2012) and in this last decade, it has become an important target during coaching routines with unstable equilibrium conditions to stimulate the deep core muscles (Schmidt & Lee; 2011).

For these reasons, the use of stabilometric systems has become functional for an objective evaluation of the COP during the evaluation of an intervention's efficacy (training, rehabilitation, orthodontic or orthopaedic) in both static and dynamic conditions.

This approach improves the knowledge of the posture and body arrangement during the performance, when the action is complex and rapid. The accuracy of balance measuring and its applicability for practical use is a challenge for device developers (Hartmann et al., 2009; Panero et al., 2018). For example, three-dimensional motion analysis systems (Merriaux et al., 2017) measure movements with a high degree of precision but are expensive, technically difficult to use, and labour intensive, and therefore not easily applicable to practical settings (Panero et al., 2018). Instead, the baropodometric platforms are commonly used in practical settings and in a laboratory, allowing technicians and researchers to decrease the preparation time of the subjects for the test (Correale et al., 2021).

Nowadays, new progress has become essential: from general to specific. Indeed, after a robust definition of tools and procedures, the new approach for a practice assessment in sport is a fit-real-life protocol. In other words, the assessment should closely tend to the real practice/action of a sport movement.

PROBLEM AND AIM

In light of this view and considering the skiing and skiers' evaluation, why do we measure the COP in barefoot condition when his performance is supported by boots?

Why do we impose unique standing "steps" when each person uses his own foot widths?

Why assess the COP (as an index of balance ability) in barefoot condition or with training-shoes when the skiers have to maintain the stance with restricted tibio-tarsal movements only in flexion and extension, and the general balance is managed with locked ankles (boots) and the movement of the COM is modulated through another tools (i.e., ski edges on snow)?

These are the questions that led us to the rationale for this pilot study that aimed to verify the COP sway differences in high-level skiers with bare feet or wearing their own boots.

METHODS

Subjects

Twenty adolescents practicing alpine skiing at a professional level and participating in national championships took part in the comparative study after their parents/legal guardians signed the informed consent to adhere to the experimental procedures. In particular, the athletes had an average ski experience of eight years with a minimum annual ski practice of 500 hours and 150 dedicated to the training condition. All of them were in the first twenty positions in the National ranking

Demographic Characteristics				
Subjects	Age (y)	Weight (Kg)	Height (cm)	BMI (Kg/m^2)
M1	12	32	135	17.56
M2	12	37	160	14.45
M3	14	50	172	16.90
M4	12	56	164	20.82
M5	11	40	140	20.41
M6	12	41	142	20.33
M7	11	28	135	15.36
M8	11	42	140	21.43
F1	16	67	168	23.74
F2	13	59	170	20.42
F3	13	46	152	19.91
F4	14	50	154	21.10
F5	13	52	160	20.31
F6	11	45	153	19.22
F7	16	63	174	20.81
F8	17	54	155	22.48
F9	17	61	163	22.96
F10	12	51	140	26.02
F11	13	50	160	19.53
F12	12	40	158	16.02

Table 1 : Anthropometric Characteristics of Skiers

Procedures

At the end of the summer training period and before the competitive season, the athletes were invited to carry out a stabilometric test lasting 30 seconds in a rest condition.

They randomly carried out the test without shoes (barefoot) and with their own ski boots (boots) on the ProKin252 platform (Tecnobody, Dalmine, Italy). A period of 30 minutes elapsed between the tests conditions to minimise the learning effect (Lovecchio et al., 2017).

Data analysis

The stabilometric platform software allows to view the COP sway measure outcomes in real time and at the end of each test. In particular, it measures the length of the COP displacement or sway (SL; mm) and the standardised ellipse area (EA, mm^2) that contains 95% of the generated path. The software also provides the average speed (mm/sec) of the COP displacement, distinguishing lateral (SML; mm/sec) and antero-posterior (VAP; mm/sec) components.

Statistical analysis

Microsoft Excel was used to input all data in a stand-alone database. All data were analysed using Prism 9.0 for Mac. A paired t-test was used to elucidate the differences between subjects that complete the test barefoot or with boots for each item (SL, EA, SML, SAP), in boys, girls and both sexes. Furthermore, the percentage difference between the two conditions for both axes (SML, SAP) in boys (B), girls (G) and both sexes were also calculated. The significance level was set at 5%.

RESULTS

The comparison of EA values between barefoot and boots condition showed high significant differences in boys ($p < 0.001$, $\eta^2 = 0.574$), in girls ($p = 0.040$, $\eta^2 = 0.177$) and in the pooled group ($p < 0.001$, $\eta^2 = 0.289$), while the SL did not reveal any significant differences between groups (Figure 2): boys ($p = 0.807$, $\eta^2 = 0.004$), girls ($p = 0.565$, $\eta^2 = 0.015$) and both sexes ($p = 0.552$, $\eta^2 = 0.009$).

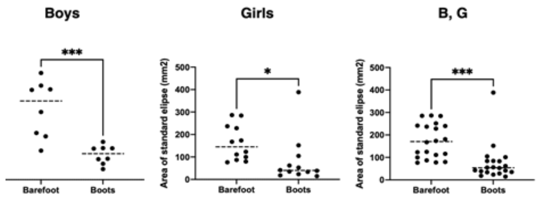

Figure 1. Comparison of the area of standard ellipse between barefoot and boots condition: B: boys; G: girls; both sexes (B, G)

Note: *** p < 0.001; *p = 0.040

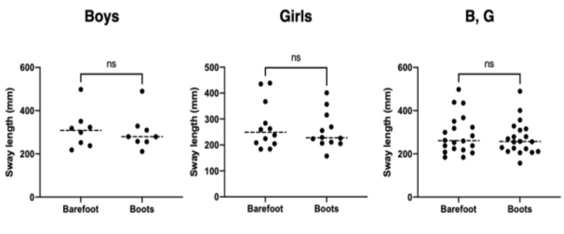

Figure 2. Comparison of the COP sway length between barefoot and boots condition. B: boys; G: girls; both sexes (B, G)

In general, the SML speed was 5.82, 5.38 and 5.56 mm/sec, respectively, for boys, girls and both sexes who performed the test barefoot. By contrast, 4.97, 4.09 and 4.44 mm/sec was measured for boys, girls and both sexes who performed the test with boots (Figure 3, upper panel).

SAP (figure 3, bottom panel) speed was 7.29, 6.14 and 6.60 mm/sec, respectively, for boys, girls and both sexes who performed the test barefoot, while 7.58, 6.47 and 6.91 mm/sec was measured in the test with boots.

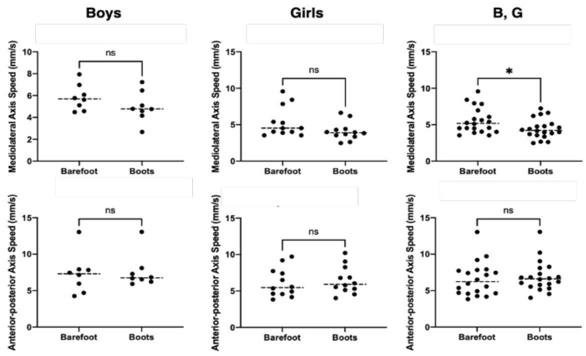

Figure 3. Comparison of mediolateral axis speed (first) and anterior-posterior axis speed between subjects that complete the test barefoot or with boots in boys, girls and both sexes (B, G)

Note: *p = 0.029

Considering the speed of COP displacement, a significant difference emerged only in the group of both sexes (B, G) ($p = 0.029$, $\eta^2 = 0.119$) and only in SML axis speed.

The SML percentage reduction overreaches 15% in boots condition in respect of the barefoot one (Figure 4).

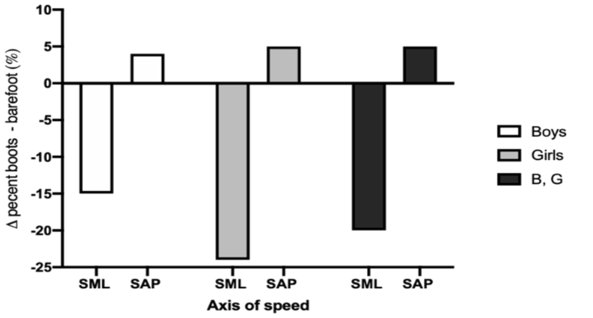

Figure 4. Percentage differences between the two conditions for both axes (SML, SAP) in boys, girls and both sexes (B, G).

Note: SML = lateral components, SAP = antero–posterior components. Percentage difference = ((Boot - Barefoot)/Barefoot) x 100

DISCUSSION

This short comparative study sought to highlight how balance is highly discipline-specific in skiing.
Firstly, at a human level, balance is managed by an overlapping of (Wade & Jones, 1997): reflex, automated and voluntary (cortical) interventions. Thus, the synergy of the three levels of the nervous system makes it hard to study balance as a scientific assessment, mostly due to the low repeatability in long term conditions (Lovecchio et al., 2017). Furthermore, laboratory conditions usually “force” the natural stance of the subjects who immediately perceive internal forces of imbalance (Sforza et al., 2006). At the same time, scientific evaluations in cross-sectional or longitudinal studies must refer to standard procedures. For these reasons, the authors of the present study aimed to demonstrate that it is important to eliminate, as far as possible, confounding or limiting factors such as the barefoot evaluation for healthy subjects who need to know the “control system” variations in race conditions.

In light of this, our comparison between the evaluations carried out barefoot and with boots is very explanatory.

The motor control system during balancing seems to follow a very different pattern/schema (Latash, 2012). Indeed, the EA is reduced (up to 70% refracted) in the boots condition, compared to barefoot, while the SL resulted in an unchanged state. As already demonstrated after strength training protocols (Sforza et al., 2013), these results suggest that the skiers, wearing the boots, interpreted the balancing control with less amplitude but with the same SL: this appears as a movement with more micro-oscillations (improvements in frequency).

Skiers kept the speed of movement in the latero-lateral direction (Batista et al., 2014) as well as in the antero-posterior direction, which is probably their typical tendency of the race gesture.

Summarising, these results showed that the assessment with boots is different than the usual setting, whereas the athletes performed the trial in barefoot condition. Which is the correct way? In our opinion the evaluations are more in line with the race gesture or that which better simulates the body arrangement of the discipline, i.e., the use of boots. In fact, the boots condition revealed a very different gesture: effective reduced displacement and SML with a mean percentage reduction of 20% (Fig 4).

From a functional point of view, specifically for the setting of physical training, the training of balance sessions could be performed wearing boots and focusing on the AP direction.

On the other hand, it would be interesting to pay attention to the SAP movements which, with the help of a technician, could be better oriented thanks to our results. In this light, technicians should evaluate if it is always correct to block some movements when these are specific to the interpretation of a sporting gesture. Also, during the physical preparation sessions, technicians should include specific exercises with the use of the boots and with a different training stimulus.

Moreover, to better accomplish the performance enhancements, it would be appropriate to evaluate whether the design of the boots considers the functional balance (Schmidt & Lee; 2011).

According to our research, there are no studies with this aim, but it is limiting to treat the boot complex (ski/plate/binding) only as a tool to transfer forces for the maximum race performance. In fact, in physical training, the race postural attitude of ankle dorsal and plantar flexion of an athlete is altered influencing the knee flexion and the power output of the lower limbs during extension (Neumann, 2008; Winter, 1990).

Considering this view, the study of a boot should also be focused on the amelioration of balancing movements.

CONCLUSION

This new approach to evaluate athletes wearing their tool suggests a more functional approach to training because the final performance should be considered as a holistic interrelation between the athlete, shoes, tool, technique, condition, and environment.

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NOVO OBRAZLOŽENJE PROCJENE RAVNOTEŽE KOD SKIJAŠA

Kontrola ravnoteže je ključna za poboljšanje izvedbe te je u ovoj posljednjoj deceniji postala ključni cilj tokom treninga sa nestabilnim uslovima ravnoteže. Širenje višestrukih pristupa za procjenu ravnoteže je poboljšalo znanje o držanju i poravnanju tijela tokom izvedbe kada je radnja složena i brza poput skijanja. Cilj ove studije je procijeniti ravnotežu skijaša u ekološkom stanju (sa pancericama) u odnosu na tradicionalni način (bosih nogu). Dvadeset adolescenata koji se bave alpskim skijanjem, a koji su učestvovali na državnim prvenstvima, je učestvovalo u ovoj komparativnoj studiji. Sportisti su izvodili stabilometrijski test u trajanju od 30 sekundi u stanju mirovanja. Test su nasumično izvodili bez cipela (bosi) i sa vlastitim skijaškim čizmama (pancericama) na balans platformi. 30 minuta je prošlo između uslova testiranja kako bi se efekat učenja sveo na minimum. Poređenje vrijednosti površine elipse između stanja bosih nogu i sa pancericama je pokazalo visoke značajne razlike kod dječaka ($p < 0{,}001$, $\eta^2 = 0{,}574$) i kod djevojčica ($p = 0{,}040$, $\eta^2 = 0{,}177$), dok dužina pomaka COP-a ili ljuljanje nije pokazalo značajne razlike. Procjena sa pancericama je drugačija od uobičajene situacije gdje sportisti ispitivanje izvode bosih nogu što ukazuje na funkcionalniji pristup treningu jer konačnu izvedbu treba posmatrati kao holistički međuodnos između sportiste, obuće, alata, tehnike, stanja i okruženja.

Ključne riječi: ravnoteža, profesionalni skijaši, skijanje, pancerice, funkcionalna evaluacija

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