The association between ankle strength, postural stability and regular slacklining

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Abstract
The aim of the study was to assess ankle strength during plantar and dorsal flexion, and the postural stability in slackliners. The slackliners (n=9) were matched according to age, body mass and height to physical education students (n=9) with no slackline experience. The results showed significantly higher relative ankle strength during plantar flexion (angular velocity 30°. s-1) in the slackline group than in the control group (left: 1.51 ± 0.31 vs. 1.20 ± 0.30 N. m. kg-1, p<0.05, ηp2=0.21; right: 1.55 ± 0.34 vs. 1.21 ± 0.34 N. m. kg-1, p<0.05, ηp2=0.22). There were no significant differences between the groups in other tested variables. The results might be considered in the injury prevention and rehabilitation of the ankle joint.

Key words
slackline, isokinetic strength, ankle joint, postural stability

Introduction

Postural stability is simultaneously influenced by visual control, vestibular apparatus, and proprioception (Giagazoglou, Amiridis, Zafeiridis, Thimara, Kouvelioti, & Kellis, 2009). Training on unstable surfaces (Laudner & Koschnitzky, 2010; McKnight & Armstrong, 1997) and vibrating supports (Evangelos, Georgios, Konstantinos, Gissis, Papadopoulos, & Aristomenis, 2012) has been found to increase the proprioception and functional capacity of the lower joints. Several studies (Aydin, Yildiz, Yildiz, Atesalp, & Kalyon, 2002; Horvat, Ray, Croce, & Blasch, 2004; Maki, Holliday, & Topper, 1994) have stated that lower limb strength is a determining factor of good postural stability. Poor postural stability is associated with lower ankle strength (Maki, Holliday, & Topper, 1994; Perry, Carville, Smith, Rutherford, & Newham, 2007) and knee strength (Jadelis, Miller, Ettinger Jr, & Messier, 2001; Messier, Glasser, Ettinger Jr, Craven, & Miller, 2002).

Walking on a slackline is a rapidly expanding physical activity. A slackline is a webbing 2-5 cm wide, usually 5-25 meters long, stretched tight between two anchor points. The basic skill on the slackline is to keep balance on one leg. Other exercises include walking, jumping and balance movements. A good level of postural stability has been associated with slackline practice (Granacher, Gollhofer, & Kriemler, 2010). Pfusterschmied, Buchecker, Keller, Wagner, Taube, & Muller (2013) showed better postural stability after 4 weeks slackline training in young adults. However, Granacher, Iten, Roth, & Gollhofer (2010) did not support the relationship between postural stability and slackine practice.

Therefore, the aim of this study was to compare postural stability and ankle strength in slackliners to that of other physically active individuals.

Methods

Subjects

Eighteen participants, divided into 2 groups, volunteered for the study. The first group was formed by "slackliners" (1 female and 8 male, 25.0 ± 0.9 years, 73.3 ± 8.9 kg and 181.0 ± 8.0 cm). To be placed into the slackline group, individuals had to walk on 2.5 cm wide webbing for 10.2 meters and perform the following exercises: standing on the right and left leg, move back and forward with a vertical turn, jump from the ground onto the slackline, walk with hands on hips. The control group of physical education students with no slackline experience was matched according to age, body mass and height (1 female and 8 male, 22.9 ± 0.8 years, 73.3 ± 8.9 kg and 181.0 ± 8.0 cm). The research was approved by the local Ethics Board.

The ankle strength measurement

Ankle strength was tested by the isokinetic dynamo-

meter (Cybex NORM ®, Humac, CA, USA). Strength testing was performed in a lying position where the tested limb was supported by a stabilizer with the knee at an angle of 90°. The second leg was supported on a stable adapter. The test protocol consisted of two angular velocities (30° . s-1 and 120° . s-1) with 5 respective 15 repetitions of plantar and dorsal flexion. The range of motion was set to 90°.
The ankle strength was assessed by the peak torque (PT) related to the body mass and the time to achieve peak strength (TP).

Postural stability

The postural stability was tested by one leg stance (Flamingo) for 63 s on a pressure plate (FootScan ®, Belgium). The total trajectory way (TTW) of the centre of pressure (COP) was used to evaluate the level of postural stability. Both right and left leg were tested. The free leg was bent at the knee at approximately 120°. The reliability of the TTW of COP in the Flamingo test was found to be satisfactory with an intra-class correlation coefficient ranging from 0.87 to 0.90 (Baláš & Zahálka, 2011).

Statistical analyses

Means and standard deviations were used to characterise the groups tested variables. Differences between the groups were assessed by a simple analysis of variance. Statistically significant differences were considered at the level $p < 0.05$. Partial coefficient eta squared ηp2 was used to assess the effect size. All statistics were computed by SPSS for Windows Version 11.0 (Chicago, IL, USA).

Results

The results of the postural stability and the isokinetic ankle strength are summarized in table 1.

Table 1:
Postural stability and isokinetic ankle strength in dorsal and plantar flexion (mean±SD) in slackline and control group

Variables		**Slackline group (n=9)**	**Control group (n=9)**
Postural stability	COP TTW L (mm)	900±199	867±421
	COP TTW R (mm)	797.2±134.1	793.3±161.8
Isokinetic ankle strength 30° . s^{-1}	PF PTrel. L (N . m . kg^{-1})*	1.51±0.31	1.20±0.30
	PF PTrel. R (N . m . kg^{-1})†	1.55±0.34	1.21±0.34
	DF PTrel. L (N . m . kg^{-1})	0.50±0.11	0.41±0.07
	DF PTrel. R (N . m . kg-^{1})	0.47±0.07	0.45±0.11
	PF TP L (s)	0.46±0.08	0.48±0.08
	PF TP R (s)	0.49±0.06	0.48±0.11
	DF TP L (s)	0.48±0.13	0.53±0.22
	DF TP R (s)	0.48±0.16	0.53±0.16
Isokinetic ankle strength 120° . s^{-1}	PF PTrel. R (N . m . kg^{-1})	0.8±0.15	0.71±0.16
	DF PTrel. L (N . m . kg^{-1})	0.79±0.21	0.75±0.2
	DF PTrel. R (N . m . kg^{-1})	0.28±0.09	0.24±0.05
	PF TPrel. L (N . m . kg^{-1})	0.27±0.08	0.21±0.06
	PF TP L (s)	0.25±0.04	0.23±0.05
	PF TP R (s)	0.24±0.03	0.22±0.03
	DF TP L (s)	0.16±0.02	0.12±0.07
	DF TP R (s)	0.14±0.02	0.13±0.04

* $p<0.05$, ηp2=0.21; † $p<0.05$, $\eta_p^2=0.22$.

Parameters: COP-Centre of pressure, TTW- Total trajectory way, L- left ankle, R- right ankle, PF- plantar flexion, DF- dorsal flexion, PT- peak torque, rel.- relative value, related to body weight, TP-time to peak.

There was significantly higher ankle strength in plantar flexion (30° . s^{-1}) in slackliners than in the control group for both ankles (left: 1.51 ± 0.31 vs. 1.20 ± 0.30 N . m . kg^{-1}, $p <0.05$, $\eta_p^2 = 0.21$, right: 1.55 ± 0.34 vs. 1.21 ± 0.34 N . m . kg^{-1}, $p<0.05$, $\eta_p^2 = 0.22$). We did not find significant differences for other parameters (Table 1). We can only state higher, but not significant, relative strength at 120° . s^{-1} in the slackline group.

Discussion

In the current study, we found that the slackliners had significantly higher relative ankle strength for plantar flexion than the control group at angular velocity 30°.s-1. At higher angular velocity (120°.s-1), there were no significant changes. Granacher, Muehlbauer, Maestrini, Zahner, & Gollhofer (2011) used the vertical jump to assess ankle strength after slackline training, but did not found any improvements, which might have been associated with the strength testing eliciting high speed contractions.

Schweizer, Bircher, Kaelin, & Ochsner (2005) reported high ankle strength and postural stability in climbers. The climbers were characterized by a significantly higher relative ankle peak torque of plantar flexion than soccer players (1.85 ± 0.2 vs. 1.52 ± 0.3 N.m.kg-1, $p < 0.05$). There were no differences for the plantar extension (0.52 ± 0.07 vs. 0.53 ± 0.07 N.m.kg-1). The current study stated similar results for ankle strength. Both slacklining and climbing are characterized by precise and slow movements in order to stabilize the body position. Therefore, the stabilizing movements on a small support area might be associated with higher ankle strength. Contrary to Schweizer, Bircher, Kaelin, & Ochsner (2005) study, we could not confirm better postural stability in slackliners.

There are contradictory results in postural stability in slackliners among published research studies (Granacher, Iten, Roth, & Gollhofer, 2010; Granacher, Muehlbauer, Maestrini, Zahner, & Gollhofer, 2011; Pfusterschmied, Buchecker, Keller, Wagner, Taube, & Muller, 2013). Granacher, Iten, Roth, & Gollhofer and Granacher, Muehlbauer, Maestrini, Zahner, & Gollhofer (2010; 2011) reported no improvements in postural control after slackline training sessions. The authors used the trajectory of COP on a pressure or force plate to evaluate the changes in postural stability. Pfusterschmied, Buchecker, Keller, Wagner, Taube, & Muller (2013) found significant improvement in postural stability using 3D motion analysis to assess the trajectory of centre of gravity. The different methods might be the reason for the results' discrepancies. As already stated by Ruhe, Fejer and Walker (2011), the measurement of COP is not a true record of body sway but rather a measure of the motor system activity in moving the COP. In the current study, we used the trajectory of COP and could not confirm better postural stability in slackliners. It corresponds to the hypothesis that the COP measurement might not be a suitable means to assess postural stability in slackliners.

The main limitation of the study is the small sample.

Conclusion

We found that the slackliners had significantly higher isokinetic ankle strength during slow speed than the control group. There were no significant differences in postural stability and higher speed isokinetic strength. The results might be considered in the injury prevention and rehabilitation of the ankle joint.

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