FUNCTIONAL UNSTABLE ANKLES AND BALANCE TRAINING

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ABSTRACT
Functional ankle instability is a condition that common occurs after an ankle sprain. However, balance training effectively reduced the risk of a recurrent ankle sprain in sport participants. Purpose: The purpose of this study was to determine the effectiveness of two different balance training programs (in stable or unstable surface), on balance ability in subjects with functional unstable ankles. Thirty-nine subjects with ankle joint instability (wrestling athletes, judo athletes and athletes doing weight training) were randomly divided into three groups, thirteen individuals each. One subject group underwent no specific balance training (Control group). The remaining two groups followed an intervention balance program for 6 weeks, 3 times per week, 20 min, using different kinds of balance exercises. One of the two training groups performed balance exercises on the floor (stable surface) with perturbation on the upper body "FB", and the other balance exercises on BOSU® ball (unstable surface) "BB". Before the beginning and after the completion of the balance program, all subjects performed static and dynamic balance tests on the balance system (deviations and targets) and on balance boards. Results: No differences ($p>0.05$) were found in all balance tests between the Initial and Final measurements in the control group. The FB and BB improve significant their performance after the completion of the training period. The BB group exhibited a greater balance improvement than FB group. Conclusions: This study suggests that balance exercises improve balance ability in subjects with functional unstable ankles, even exercises performed on a stable surface, with the proper perturbations of the upper body.

Key words: proprioception, perturbation, unstable surfaces, wrestling

INTRODUCTION

Lateral ankle sprains are one of the most prevalent injuries in high school, collegiate, and recreational sports (Buchanan et al., 2008; Bellows & Wong, 2018). Ankle sprains occur in sports that require quick direction changes, cutting movements, and rapid acceleration and deceleration (Bahr, 2002). Wrestling is one of the most mentally and physically demanding sports. However, as expected in a physical contact sport such as wrestling or judo, the athletes are prone to occasional injury. Wrestling injuries account for the second most frequent sports injuries after football (Centers for Disease Control and Prevention, 2006). Lateral ankle sprains are one of the most prevalent injuries in high school, collegiate and recreational sports (Buchanan et al., 2008). According to the United States National Collegiate Athletic Association (NCAA), the most commonly injured body part was the knee at 21% of all reported wrestling injuries, while the ankle was the third most common injury at 9% (Newton et al., 2002). Similarly, many investigators reported that in collegiate wrestling, the ankle joint was one of the most commonly injured regions (Jarrett et al 1998; Agel 2007; Yard et al 2008; Shadgan et al., 2010).

Functional ankle instability is a condition that occurs after an ankle sprain in approximately 40% of patients (Freeman, 1965). There are varies definitions of functional ankle instability (FAI) in the literature, including the "disabling loss of reliable static and dynamic support of a joint" (Vaes et al., 1998), and a "tendency for the foot to give way" (Freeman, 1965B).

Functional instability is primarily identified by self-reported instability during activities of daily living or functional activity (Buchanan et al., 2008; Docherty et al., 2005; Munn et al., 2002). Impairment of the ability to maintain unilateral postural balance has been found to be highly correlated with functional instability of the ankle (Bernier and Pierrn, 1998 Sodermank et al., 2000), which could lead to deficits such as increased postural sway that have been identified in subjects with a history of functional ankle instability (Cornwall and Murrel, 1991; Evans et al., 2004). This may be due to factors such as proprioceptive deficit, delayed peroneal reaction time, and peroneal weakness (Karlsson and Lansinger, 1993). However, single-limb postural sway has been examined in subjects with a history of FAI and healthy controls, but the results are equivocal (Cornwall and Murrel, 1991; Dochertyet al., 2005; Evanset al., 2004; Jerosch and Bischof, 1996).

As far as intervention programs for the prevention and treatment of acute lateral ankle sprains and functional unstable ankle are concerned, their common components are balance and coordination training (Mattacola and Dwyer, 2002). Freeman et al (1965) hypothesized that balance and coordination training could diminish proprioceptive deficits associated with ligamentous injury to the ankle. In a systematic review and meta-analysis, Schiftan et al. (2015) concluded that balance training effectively reduced the risk of ankle sprain in sport participants with a history of ankle sprains.

There are many different methods commonly used to train balance. The types of these exercises can be grouped in two different categories, the “static” and the “dynamic” balance exercises. “Static exercises” require that the athlete’s foot remain in the same position with the movement in the center of gravity. In order to maintain static balance the athlete must make many small corrections at the ankle, hip, trunk, arms, or head in an attempt to maintain balance. On the other hand, dynamic balance requires the athlete to move outside his or her normal base of support (Houglum and Perrin, 2001).

The effectiveness of training on an unstable surface in non-impaired individuals (Hoffman and Payne, 1995; Mattacola et al., 1995; Caraffa et al., 1996; Gioftsidou et al., 2006; Malliou et al., 2004; Malliou et al., 2008) and in individuals with functionally unstable ankles (Gauffin et al., 1988; Bernier and Pierrn, 1998; Perronet al., 2007) has been investigated and documented by various researchers. However, often the appropriate equipment (unstable surfaces) is not available to work balance ability. Whether balancing ability could be improved by performing one leg stance exercises on stable surface and changing the center of gravity with perturbations in the upper body has not been examined in both healthy and functionally impaired individuals.

In light of these important considerations, we have sought to: 1) determine the extent to which a previous ankle sprain and a self-reported instability affects the persons balance ability, and 2) investigate whether a balance-training program, on different surfaces, performed by people with functional ankle instability could have different effects on their balance ability.

MATERIAL AND METHODS

Participants

Thirty-nine college-aged individuals volunteered to participate in this study. The participants were participating in in the sports of wrestling or judo at the recreational or varsity level at least twice each week, or participating in weight training at least twice each week. The participants were divided into three groups: 1. Balance exercises on the floor with perturbation on the upper body “FB”, (age=21.12±1.45years, height=172.9±11.1cm, mass=73.89±14.23kg) 2. Balance exercises on bosu “BB” (age=21.29±1.21 years, height=173.8±11.9 cm, mass=75.35±11.39 kg), 3. Control (age=21.22±1.70 years, height=173.6±9.1 cm, mass=76.35±10.52 kg). Participants were included in the FB and BB group if they had a history of moderate to severe ankle sprains and residuals episodes of giving way or instability while engaging in recreational or competitive sport activities. Subjects in the FB and BB group had one ankle identified as unstable and one as stable. Participants were included in the control group if they had no history of ankle sprains. On the basis of self-reported dominance, the control group had limbs identified as dominant (D) or non-dominant (ND). Exclusion criteria for both groups included a history of lower extremity surgery or fracture, moderate injury to a knee or hip, or osteoporosis. The experimental procedures were in accordance with ethical standards of the Committee on Human Experimentation at the Institution where the work was conducted and with the Helsinki declaration of 1975. The two training groups FB and BB performed balance exercises for 6 weeks, 3 times per week, 20 min per session.

Balance assessment

The balance ability of all participants was assessed at baseline and after the completion of the 6-week balance-training programs. The balance ability assessment was performed with three different balance boards (boards 1a, 1b, and 2) and the Biodex Stability System (Arnold and Schmitz, 1998; Biodex Stability System, 1998; Paterno et al., 2004; Rein et al., 2011; Rein et al., 2011B). Board 1a restricted movement in the anteroposterior direction only, board 1b restricted movement in the medio-lateral direction only, and board 2 allowed movement in both antero-posterior and mediolateral directions. In the balance board tests, the subjects maintained single-limb stance for as long as possible. Three test trials were timed on each balance board and the best trial was considered for further analysis. Assessment was performed with the Biodex Stability System. The participants maintained single-limb stance (injured leg for the FB and BB group), with the Biodex platform set to freely move by up to 20° from level in any direction. At the first test, from the variance of the platform displacement (°) in the anterio-posterior and medio-lateral directions from level during the 20s test, an instability index (Ii) was computed from the Biodex system. Three test trials were carried out and the one with the lowest Ii (best performance) was further processed (Figure 1). At the second test participants attempt to move the cursor, depicting the position of the body center of mass, to a specific target on the Biodex system screen (Figure 2). The test finish when the participant “catch” the first 5 targets. Three test trials were timed and the best trial was considered for further analysis.

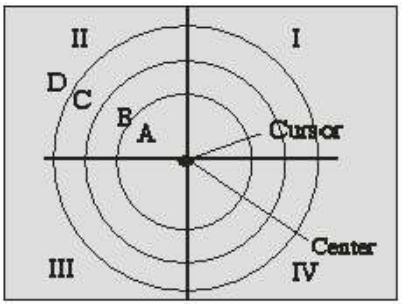

Figure 1. Biodex system screen, where participants attempt to keep the cursor at the center of the bullseye

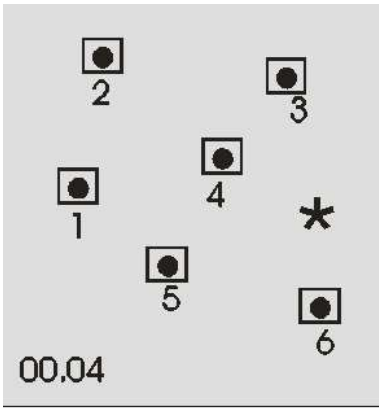

Figure 2. Biodex system screen, where participants attempt to move the cursor to a specific target

Balance training

FB group training: perform one leg balance exercises on the floor trying to changing the center of gravity, by changing the position of the other leg, by bending the torso, by disrupting the position of the upper body with a swiss ball, by pulling with an elastic band. They performed 20 sets of 45s attempt and 15s rest.

BB group training: perform one leg balance exercises on an unstable surface, on a bosu (at both sides), trying to keep their balance and performing the appropriate correction movements. They performed 20 sets of 45s attempt and 15s rest

Statistical analysis

A student's *t*-test used to test for differences between the stable and unstable ankle, and between dominant and non-dominant leg. Two-way repeated measures ANOVA was used to test for differences in balance ability in the FB, BB and Control group between the Initial and Final measure (3·2). The Scheffe´ test was used for post hoc analysis where appropriate. The level of statistical significance was set at $p<0.05$.

RESULTS

At the initial measurement in all balance tests there were no differences between dominant and non-dominant leg for the control group ($p>0.05$). However, the FB ($p<.05$) and BB ($p<01$) group revealed statistically significant differences between the stable and unstable ankle (Table 1). No difference ($p>0.05$) in balance ability was found in the control group between initial and final measure, for the dominant (D) and the non-dominant leg (ND). In contrast, the 6-week balance training program improved all the balance performance indicators examined in the FB and BB groups. More specifically, with regard to the Biodex assessment, the improvement in balance ability for the injured leg was greater ($p<0.01$) in the BB group than the FB group ($p<0.05$) at the first assessment (deviations). Similarly, for the second test (targets) an improvement in balance ability for the injured leg was greater ($p<0.01$) in the BB group than the FB group ($p<0.05$). For all the tests performed on balance boards, the improvement in balance ability for the injured leg was greater ($p<0.01$) in the BB group than the FB group ($p<0.05$) (see Table 1).

Table 1. Balance assessments

	Pre-Training				Post Training		
	Limb	**FB**	**BB**	**Control**	**FB**	**BB**	**Control**
Ii (°)	**Healthy / D**	3.21±1.8	3.22±1.2	3.55±1.4	3.23±1.5	3.29±1.5	3.51±1.6
	Injured / ND	7.42±2.7	7.56±2.7	3.32±1.2	4.76±2.9*	3.32±1.4**	3.47±1.7
Targets (s)	**Healthy / D**	2.23±1.4	2.43±1.3	2.12±1.1	2.24±1.1	2.32±1.2	2.13±1.5
	Injured / ND	6.21±2.2	6.97±2.6	2.14±1.4	3.13±2.7*	2.39±1.2**	2.21±1.3
Board 1a(s)	**Healthy / D**	9.3 ± 2.22	9.4 ± 2.43	10.6 ± 2.5	9.09±0.7	9.15±3.7	10.68 ±2.2
	Injured / ND	4.3 ± 1.2	4.13 ± 1.4	9.67 ± 2.1	7.87±3.9*	9.34±3.3**	9.71 ±2.7
Board 1b(s)	**Healthy / D**	7.38±2.06	7.63±2.87	7.45±2.34	7.24±1.5	7.64±2.1	7.52±2.65
	Injured / ND	2.38±1.6	2.75±1.9	7.67±2.19	5.43±2.4*	7.58±2.3**	7.72±2.25
Board 2	**Healthy / D**	6.95±2.48	7.04±2.54	7.02±2.67	6.87±2.82	7.09±2.7	7.03±2.34
	Injured /ND	2.95±1.8	2.82±1.4	7.35±2.45	5.22±1.8*	6.98±3.2**	7.43±2.52

*p<.05, ** p<.01, ***p<.001

Discussion

In this study, no significant differences were found between the dominant and non-dominant ankles of the control group in all balance tests. These findings were consistent with those of Rein et al (2011), Rein et al (2011B), Cornwall et al (1991) and Mitchell et al (2008), who suggested that the control group's ankles were symmetrical. Although subjects identified their limbs as dominant and non-dominant, the performance of both ankles was similar. Therefore, it seems that no proprioceptive advantage exists when activities are carried out using either dominant or non-dominant limbs (Mitchell et al., 2008).

As far as FB and BB groups are concerned, significant differences in all balance tests between the unstable and stable ankle joint were found at the initial measurements. These results were consistent with the findings of several others studies who have found increased postural sway in ankles with a history of functional instability resulting from ankle sprain compared to healthy contralateral controls (Cornwall and Murrel, 1991; Goldie et al., 1994; Forkin et al., 1996; Akbari et al., 2006; Perron et al., 2007; Nam et al., 2018).

The findings of the initial measurement supported the necessity of application balance exercises in individuals with functional unstable ankle. Rehabilitation exercises to improve postural control include single limb balancing tasks on balance boards, balance disks and electronic balance devices (Mitchell et al., 2008). The present study tries to indicate possible effects of the performance balance exercises on a stable surface. Exercises that can be performed easily, anywhere at no cost.

Functional instability of the ankle is not an acute condition that will lead the injured athlete to visit a rehabilitation specialist. These injured athletes often do not follow a specific exercise program to improve their balance. They are athletes who continue their activity and often lead to another injury. Thus, is very useful to be able to offer them a simple exercise program that they can perform anywhere.

According to the final measurement, both training groups FB and BB significantly improved their performance. After the completion of the rehabilitation programs, no significant differences were found between the stable and unstable ankles in all balance performance indicators. The findings relevant to balance ability improvements in response to balance training agree with previous reports on sedentary individuals (Bernier and Pierrn, 1998; Gauffinet al., 1988; Rozzi et al., 1999). However, the BB group achieved a better improvement in all balance tests performance, suggesting that balance exercise performed on unstable surfaces can improve better the balance ability of individuals with functional ankle instability. It is important, however, that even exercises performed on a stable surface were able to improve balance deficits in functional unstable ankle joints.

CONCLUSIONS

This study suggests that balance exercises improve balance ability in subjects with functional unstable ankles. In the light of the present study results, the research team believe that even exercises performed on a stable surface, with the proper perturbations of the upper body, were able to improve balance deficits in functional unstable ankle joints

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