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Original Article

Effect of proprioceptive training on postural balance in patients with chronic ankle instability

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Abstract
The symptoms of acute lateral ankle sprain usually resolve quickly; approximately 40% of individuals with an initial ankle sprain will develop long-lasting symptoms (including pain, subjective instability, loss of function, and repetitive ankle injuries) that lead to constant ankle dysfunction. The threshold for sensing joint movement has been changed. As a consequence of this local proprioceptive deficit, owing to damaged peripheral proprioceptors, postural control changes occur. **The purpose** of this study is to follow the effect of proprioceptive training on postural balance and limb functioning in patients with chronic ankle instability. **Methodology**: A total of 15 young individuals diagnosed with chronic ankle instability for 6 months or more participated in the investigation. All subjects underwent 8 weeks of proprioceptive training and performed exercises for static joint position sense, movement sense, balance exercises, and plyometric-orientated skills. Before and after proprioceptive training, they were tested for static postural balance using the Stork test – eyes open and closed; to test dynamic postural balance, Star Excursion Balance Test and One Leg Hop for time were used. **Results** After 8 weeks of proprioceptive training, the Stork test with eyes open was performed to the norm using stable (30.00 s) and unstable (29.933 ± 0.258 s) legs. When vision was eliminated, the patients with chronic ankle instability showed poor balance using both stable (25.6 ± 4.032 s) and unstable (20.466 ± 5.37 s) legs The Star Excursion Balance Test showed the shortest tap distance for the unstable leg in Anterolateral (52.47 ± 4.95 cm) and Lateral (57.53 ± 2.696 cm) directions, while the highest mean increase was in the Anterior direction (d-10.867 cm, $\alpha < 0.05$). The highest difference between leg performances was in the Posterolateral (d-11.13 cm, $\alpha < 0.05$) direction. One Leg Hop test showed improvement in the time of performance using the unstable leg (4.53 ± 0.79 s) but not enough to match the time of the stable leg (3.59 ± 0.48 s). **Conclusion:** The 8-week proprioceptive training improved both the static and dynamic unilateral balance of patients with unilateral chronic ankle instability. Still, some difficulties were observed when performing dynamic balance tasks.
Keywords: unstable ankle, static and dynamic unilateral stance, proprioception.

Introduction

The lateral ankle sprain is one of the most common injuries in young and active population. In daily activities, the most common scenario is twisting the foot in inversion, while in sports actions individuals injure the ankle upon landing, when the foot goes in plantar flexion and inversion with ground contact. Participants in sports like football, basketball, and volleyball can present reinjure rates of lateral ankle sprain as high as 70-80%, and about 30-50% of these cases will develop chronic ankle instability (Postle et al, 2012; Riva et al, 2016). Although symptoms of an acute lateral ankle sprain usually resolve quickly, approximately 40% of individuals with an initial ankle sprain will develop long-lasting symptoms including pain, subjective instability, loss of function, and repetitive ankle injuries leading to a constant ankle dysfunction known as chronic ankle instability (CAI) (Gerber et al, 1998; Hertel et al, 2002). Some authors also name this condition as functional ankle instability, since the individuals complain of a sensation of "giving way" in activities of daily living when usually the ankle should sustain the strain forces. There is no requirement to define CAI, how long the symptoms should persist, which activities are limited, and how long the inability of control is present (Han et al, 2015). It occurs accidentally and often when both sensory and motor subsystems contribute to generating reactive avoidance motor strategy, to prevent the accumulated strain in the relevant tissues from reaching an injurious moment (Witchalls et al, 2014). But the threshold for sensing joint movement has been changed. As a consequence of this local proprioceptive deficit, due to damaged peripheral proprioceptors, postural control changes occur. Literature has shown that CAI is associated with poor postural control and altered motor neuron strategies (Aman et al, 2015; McKeon&Hertel, 2008; Myers et al, 2003). Patients with CAI have demonstrated altered neuromuscular strategies during functional activities like walking and jumping (Delahunt et al, 2006a,b). When walking, an increase in peroneus longus muscle activity prior to initial contact is seen, as opposed to

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healthy individuals who did so after the initial contact (Delahunt et al, 2006a). In a unilateral drop jump, patients with CAI have demonstrated less anticipatory peroneus longus muscle activity compared to healthy controls (Delahunt et al 2006b). During transition from bilateral to unilateral stance patients with CAI have exhibited a delay in onset of muscle activation and less anticipatory activation in muscles around the ankle, knee, and hip (Van Dun et al, 2007). It also is interesting that authors have described postural control impairment in the uninjured limb in patients with CAI, suggesting that recurrent sprains may be the consequences of both centrally mediated deficits and local sensorimotor insufficiencies (Evans et al, 2004).

Postural balance is an important part of many functional daily tasks. It has been classified as either static or dynamic. Static postural balance is termed as quiet standing with minimal sway and no other body movements, while dynamic balance is defined as the ability to keep postural balance as other body parts are moving (Winter et al, 1990). Authors describe differences in postural control among patients with CAI (Hertel, 2002; McKeon&Hertel, 2008) and one possible reason for that is inconsistency in inclusion and exclusion criteria when defining such patients (McKeon&Hertel, 2008). Researches measure the postural balance of CAI patients, with the One Leg Stance Test, which is more static in nature (McKeon&Hertel, 2008). Balance deficit is found in more challenging tasks, therefore more dynamic tests like Star Excursion Balance Test (SEBT) (Gribble et al, 2004) and jump landing (Ross et al, 2005) are needed.

Not all patients with laterally sprained ankle develop CAI, but the ones who do show various residual symptoms. Increased ankle laxity may influence balancing ability during different functional, sports and dancing activities (Miller et al 2018). Coping with the CAI condition is a difficult task and there is still debate on the correct way to perform the rehabilitation. One thing is the treatment program duration, which varies between 4-6-8 weeks or more. Another thing is the methods and exercises included in the treatment to overcome this postural performance deficit. Some authors emphasize on specific manual and neurodynamic techniques (Dimitrova, 2008), acupuncture massage (Tomova, 2020), to improve range of motion and function. Others compare the effect of tapping application and whether the stabilization will be increased (Eremiev, 2009; Fereydounnina et al, 2019; Raymond et al, 2012; Sykaras et al, 2018). Most of all the discussion is about the type of exercises – strength, balance, proprioceptive, functional, etc. (Eremiev&Bivolarski, 2013; McHugh et al, 2007; Shiftan et al, 2015; Wright et al, 2017), which should be in the therapeutic program for patients with the chronically unstable ankle. Some research has been done about the effectiveness of proprioceptive training for decreasing ankle sprain accidents and ankle sprain recurrences (Grueva-Pancheva&Mednikarov, 2019; Rivera et al, 2017). Treating CAI condition seems to be challenging and more evidence is needed to guide effective management. The purpose of this study is to follow the effect of proprioceptive training on postural balance and limb functioning in patients with chronic ankle instability.

Material and Methods

Participants

A total of 15 young individuals between 31 and 42 years of age (35.6 mean age) participated in the investigation. They all were diagnosed with chronic ankle instability for six months or more. The main criteria for inclusion in the study were: complaining of functional instability in the ankle during activity; at least 3 episodes of ankle sprain and with the last one being a reason for starting proprioceptive training. The exclusion condition was any other trauma of the lower limb in the last year. The females prevailed in the test group, 9 out of 15. The right leg was more often seen as dominant, while the left one was more sprained. Limb dominance was determined by pointing the preferred limb for kicking a ball. All the anthropometric data of the subjects are presented in Table 1.

Table 1. Anthropometric characteristics of all investigated subjects

Parameter	Subjects (n=15)
Male	6
Female	9
Age (years)	35.6±7.1
Height (cm)	169.5±5.3
Weight (kg)	69.3 ±6.3
Right dominant leg (n)	9
Right unstable leg (n)	6

All participants in the investigation were volunteers, non-professional athletes, with active sports participation 1-3 times a week. Most of the patients were injured during a sports activity. All participants gave their signed informed consent to participate in the study in accordance with the ethical standards of the local Ethics Committee and the Helsinki declaration. The participants were free to withdraw from the study at any time.

Proprioceptive training

All tested subjects underwent 8 weeks of proprioceptive training. The training started in the sub-acute period after the last ankle sprain. Our proprioceptive program included proprioceptive exercises for static joint position sense, movement sense, balance exercises, and plyometric-orientated skills. In the beginning, if symptoms were present while loading the leg when standing, we would start exercise when sitting on a swissball or standing and using hand support. The first and most important part was teaching the patients to keep the foot's neutral position while stepping on surface (Figure 1). This neutral position should be kept during any other exercise of the proprioceptive program. Later the hand support was removed, then shifting from bilateral standing towards unilateral standing, and finally additional elements like head and arm movements were added.

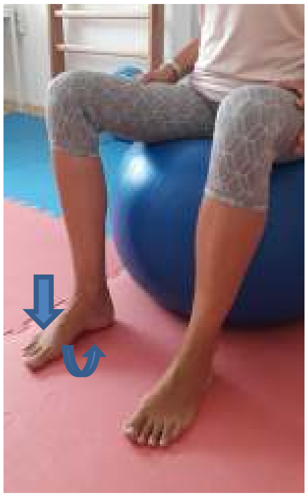


Figure 1. Foot in neutral position


Figure 2. Exercise on labile surface


Figure 3. Ball distraction exercise

At first the exercises were performed in front of a mirror for self-control and constant correction, then the mirror was removed, and later with eyes closed. The stable surface was replaced with an unstable one through the use of a balance board, discofit, and mini-trampoline. On the balance board they first started with uniaxial movements (sagittal, frontal dimension), followed by biaxial movements (diagonal board placement), and finally triaxial and multiaxial movements (dome shape pivot point of the board). Once the static joint position sense is learned, more dynamic balance exercise were incorporated in the program: lift on toes, heels, inner/outer edge of the foot; mini-squats, lunges in different directions; more functional tasks like dealing with stairs, walking with changing directions on even and uneven surface. All these proprioceptive exercises were also performed on a labile surface (Figure 2), with theraband resistance and body perturbation, throwing ball distraction (Figure 3), etc. The mini-trampoline was used first as a step to get in and out, and gradually in weeks 6 to 8, the simple plyometric exercises were done in it. If no symptoms were provoked, sport-specific skills were started between weeks 4 and 5. Simple plyometric exercises and running drills were trained first in a straight line and, as a progression, with pivot shifting and more rapidly changing the direction of movement. The proprioceptive training was performed 4-5 times a week with duration between 30-45min.

Measurements

Several balance tests were used to evaluate the static and dynamic postural abilities of patients with chronic ankle instability (CAI). The Stork test assessed the static postural balance, an appropriate test to measure proprioception of the lower limb. It is especially reliable, in determining a proprioceptive deficit, when performed with eyes closed (Popov et al, 2012). The patients were asked to stand still on one leg, hands rested aside, and the foot of the other leg maintained at the knee level of the supporting leg. Both legs, the stable and the unstable one, were tested in two conditions: eyes open and eyes closed, for duration of 30 seconds. The test was done prior to the proprioceptive program and after 8 weeks of practicing.

For the dynamic postural balance abilities, the Star Excursion Balance Test (SEBT) was performed. We followed the procedure described by MAT (mat assessment technologies) (King, 2020). The sequence of measurements was as follows: Anterior (A), Anterolateral (AL), Lateral (L), Posterolateral (PL), Posterior (P), Posteromedial (PM), Medial (M), and Anterolateral (AM). First, the stable leg was measured, followed by the unstable. The supporting leg was the one being measured for dynamic balance abilities. For anterior directions, the foot was placed with the second toe on the line at 0 cm. For the posterior directions, the foot was placed with the heel on the line at 0 cm. And for mediolateral directions, the mid-part of the foot was placed at 0 cm. The free limb was then asked to reach as far as possible in the given direction and tap on the measurement line without putting weight on that foot. The hands had to be placed on the waist. The heel of the supporting leg had not been lifted off the floor, otherwise, the test was not reliable. The patients were asked to make 3 attempts in every direction with every leg and the best score was taken for statistical processing. The test was performed before starting with proprioceptive program and 8 weeks after participating in it.

The functional test Single Leg Hop for time was another dynamic test applied on the patients with CAI, which strongly provoked the antero-posterior shear forces and thus the stability of the ankle and knee joints. Every patient was assessed for the time taken to hop 6 meters on one leg. The stable leg was tested first. The procedure of evaluation was taken by McGee (McGee, 2006). As this test was more demanding for stability issues and was too risky to measure it at the beginning, we performed it at the end of the 4th and 8th week of proprioceptive training.

Statistical analysis

Mean values and standard deviation for each parameter of every test were calculated. A paired sampled t-test was used to determine if there were differences between data obtained prior to proprioceptive training and after 8 weeks of practicing the program, for each leg. Also, the differences between the legs were estimated and compared for the SEBT. The significance level was considered at $\alpha < 0.05$.

Results

Stork test

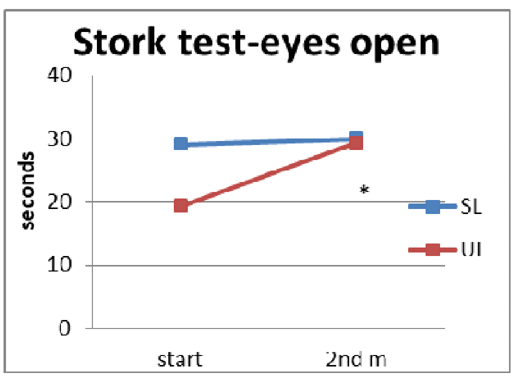
The obtained results from Stork test differed in the two performed conditions. While standing in a quite unilateral stance with eyes open, the individuals managed to keep the balance to the norm, with both legs. Only with the unstable leg before the proprioceptive training, they had difficulties to reach 30 sec (19.33 ± 2.35 s), but in 8 weeks they improved it (29.933 ± 0.26 s), and that was statistically supported ($\alpha < 0.05$) (Table 2, Graphic 1).

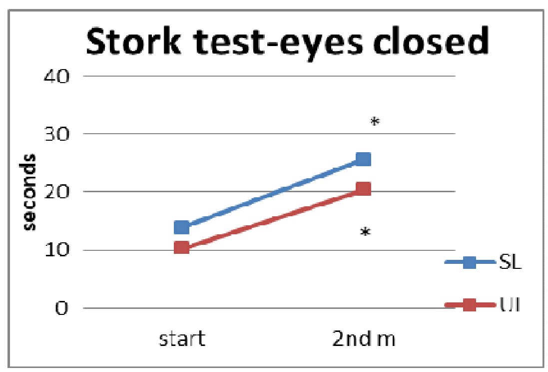
Table 2. Statistical results of Stork Test for stable (SL) and unstable leg (UL)

		start		2nd month		d	d%	d_{es}	t	P (t)
		X_1	S1	X_2	S2					
eyes open	**UL**	19.33	2.35	29.93	0.26	10.60	54.83	9.54	17.905	100
	SL	29.07	1.28	30.00	0	0.93	3.211	0	2.824	98.648
eyes closed	**UL**	10.33	4.24	20.47	5.37	10.13	98.06	1.45	12.33	100
	SL	13.93	4.98	25.6	4.03	11.67	83.73	1.57	16.32	100

X – mean values in sec., S – standard deviation, d – degrees of freedom, t – t-criteria of Student

When the vision was eliminated during the quite unilateral balance test, the patients with CAI showed difficulties to maintain equilibrium. Before performing the proprioceptive program average data for the unstable and stable leg was quite low. After 8 weeks of proprioceptive practice, they improved it from 10.33 ± 4.24 s to 20.47 ± 5.37 s for the problematic leg and from 13.93 ± 4.98 s to 25.6 ± 4,03 s for the non-problematic leg, with statistical support ($\alpha < 0,05$) (Table 2, Graphic 2). Interestingly the patients managed to keep the static balance in the same manner before and after the proprioceptive program with both legs, with slightly higher scores for the stable one.





Graphic 1.Statistical Results Stork Test – eyes open
*St. Significance between the 1st and 2nd measurement

Graphic 2.Statistical Results Stork Test – eyes closed
*St. Significance between the 1st and 2nd measurement

Star excursion balance test (SEBT)

The statistical results: mean values, standard deviations, mean differences, t-criteria, for all parameters of SEBT are presented in Table 3. There was statistical significance for increasing the touch distance after the proprioceptive training for all 8 directions and that for both legs.

The highest mean increase for unstable ankle was in the A direction (d 10.867 cm), followed by the L direction (d 5.33 cm) and AL direction (d 3.733 cm). With not such a great mean difference for the stable ankle, the biggest increase was again in A direction (d 3.93 cm), followed by AL (d 3.667 cm) and L (d 3.6 cm), showing very small differences in between.

The opposite end, with the lowest mean increase in tap distance for unstable leg, post proprioceptive training, was for the PM direction (d 1.733 cm), followed by P (d 1.933 cm) and AM (d 2.00 cm) directions. For the stable leg the lowest mean increase was in a different direction, M (d 1.4 cm), followed by AM (d 1.867 cm) and PM (d 2.067 cm). In general, the mean differences (d) in the data for the stable leg are with minimal discrepancies in between, comparing with the data of the unstable leg where they varied more (Table 3).

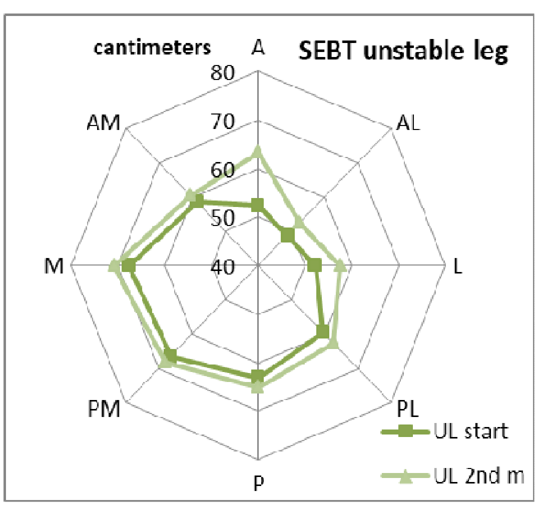
Table 3. Statistical Results of SEBT

		start		2nd month		d	d%	d_{es}	t	P (t)
		X_1	S1	X_2	S2					
Unstable leg	**A**	52.40	3.501	63.27	3.634	10.867	20.738	1.660	16.62	100.00
	AL	48.73	4.480	52.47	4.955	3.733	7.661	0.745	9.73	100.00
	L	52.20	2.178	57.53	2.696	5.333	10.217	1.471	17.58	100.00
	PL	59.53	3.502	62.40	3.225	2.867	4.815	0.793	11.21	100.00
	P	63.13	1.552	65.07	2.017	1.933	3.062	0.956	7.79	100.00
	PM	66.47	3.889	68.20	3.649	1.733	2.608	0.455	5.77	100.00
	M	67.67	1.988	70.80	2.833	3.133	4.631	1.086	4.59	99.96
	AM	58.47	2.167	60.47	2.134	2.000	3.421	0.853	7.75	100.00
Stable leg	**A**	62.60	2.098	66.53	2.031	3.933	6.283	1.381	8.50	100.00
	AL	52.93	2.154	56.60	2.501	3.667	6.927	1.240	15.78	100.00
	L	63.33	4.082	66.93	3.348	3.600	5.684	0.878	10.31	100.00
	PL	70.60	2.384	73.53	2.232	2.933	4.155	1.080	11.82	100.00
	P	71.80	2.651	74.20	2.305	2.400	3.343	0.879	6.19	100.00
	PM	72.27	2.815	74.33	2.410	2.067	2.860	0.743	5.57	99.99
	M	73.40	3.661	74.80	3.610	1.400	1.907	0.384	5.96	100.00
	AM	65.60	2.971	67.47	3.482	1.867	2.846	0.562	6.42	100.00

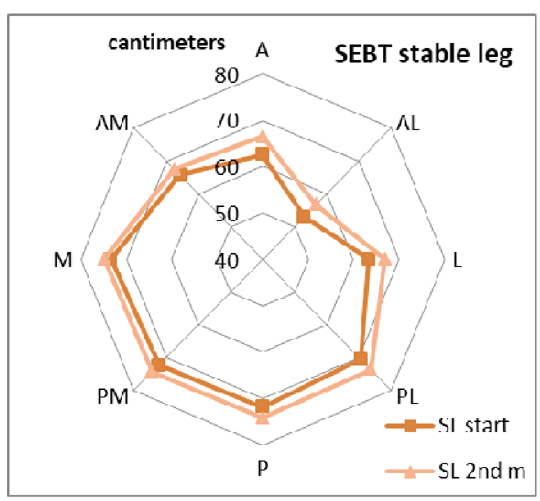
X– mean values in cm, S– standard deviation, d – mean differences (degrees of freedom), t – t-criteria of Student

A different view, for the unstable limb (Graphic 3), reveals that prior to proprioceptive training the lowest mean tap score was made in AL direction (48.73 ± 4.48 cm), followed by L (52.20 ± 2.18 cm) and A (52.40 ± 3.5 cm) directions, which results were quite close. AM direction (58.47 ± 2.17 cm) was next score, close to PL (59.53 ± 3.5 cm) score as to follow. Above 60 cm were P (63.1 ± 1.56 cm), PM (66.47 ± 3.89 cm) and M (67.47 ± 1.99 cm) directions. The same sequence is seen for the stable limb (Graphic 4), with that difference, that the scores were much higher with 5-11 cm in length, and that was statistically supported ($\alpha < 0.05$). Only in the AL direction (d -4.2 cm) the scores were closer between the limbs and no significant difference was seen ($\alpha > 0.05$) (Table 4). The highest difference between legs was in PL direction (d -11.07 cm, $\alpha < 0.05$) (Table 5).

After the proprioceptive practicing period, the order for lowest mean touch score differed a little for the unstable lower limb. Again the lowest score was in AL direction (52.47 ± 4.96 cm), followed by L (57.53 ± 2.7 cm), and then places were taken from AM direction (60.47 ± 2.13 cm), PL (62.40 ± 3.22 cm) and A (63.27 ± 3.63 cm). Again the high tap scores were in the same order, for P (65.07 ± 2.02 cm), PM (68.20 ± 3.65 cm) and M (70.80 ± 2.83 cm). The mean value of the medial tap score was the only score above 70cm for the unstable leg (Graphic 3). For the stable leg, the sequence remained the same after the proprioceptive training for 8 weeks, with very similar scores for the highest values of P (74.20 ± 2.31 cm), PM (74.33 ± 2.41 cm) and M (74.80 ± 3.61 cm) directions (Graphic 4). In most directions the obtained results for the unstable ankle were higher with 6-11 cm length, statistically supported ($\alpha < 0.05$). But here apart from AL (d -4.13 cm, $\alpha > 0.05$) (Table 4) direction, A (d -3.27 cm, $\alpha > 0.05$) (Table 4) and M (d -4 cm, $\alpha > 0.05$) (Table 5) directions also did not show statistically significant differences between the lower limbs. Again the highest difference between legs was in PL direction (d -11.13 cm, $\alpha < 0.05$) (Table 5).



Graphic 3.SEBT Unstable Leg (UL)



Graphic 4.SEBT Stable Leg (SL)

Table 4. Statistical differences between stable (SL) and unstable leg (UL) in Anterolateral (AL) and Anterior (A) direction

AL Direc	start		2nd m		A Direc	start		2nd m	
	$X_н$	$S_н$	$X_к$	S_k		$X_н$	S_k	$X_н$	S_k
UL	48.73	4.48	52.47	4.95	**UL**	52.40	3.50	63.27	3.63
SL	52.93	2.15	56.60	2.50	**SL**	62.60	2.10	66.53	2.01
d	-4.20		-4.13		**d**	-10.2		-3.27	
t	3.27		2.88		**t**	9.68		3.04	
P(t)	**99.72**		**99.25**		**P(t)**	100		**99.49**	

X – mean values in cm, S – standard deviation, d – mean differences, t – t-criteria of Student

Table 5. Statistical differences between stable (SL) and unstable Leg (UL) in Posterolateral (PL) and Medial (M) direction

PL Direc	start		2nd m		M Direc	start		2nd m	
	$X_н$	$S_н$	$X_к$	S_k		$X_н$	S_k	$X_н$	S_k
UL	59.53	3.50	62.40	3.22	**UL**	67.67	3.50	70.80	2.83
SL	70.60	2.38	73.53	2.23	**SL**	73.40	2.10	74.80	3.61
d	-11.07		-11.13		**d**	-5.73		-4.00	
t	10.12		10.99		**t**	5.33		3.38	
P(t)	100		100		**P(t)**	100		**99.78**	

X – mean values in cm., S – standard deviation, d – mean differences, t – t-criteria of Student

Single leg hop for time

The data from the dynamic functional test Single Leg Hop for time revealed that there was an improvement in performance with both legs. The mean test time for the unstable leg at 4th week was 5.95 ± 0.99 s, and at the end of the practicing period was 4.53 ± 0.79 s, showing an increase in the speed (d -1.425 s) and that was also statistically supported (α < 0,05) (Table 6, Graphic 5).

Table 6. Statistical results of Single Leg Hop for time for stable (SL) and unstable leg (UL)

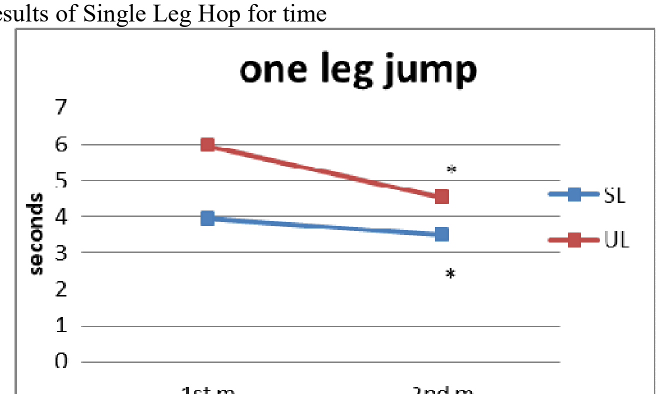
	1st month		2nd month		d	d%	d_{es}	t	P (t)
	X_1	S1	X_2	S2					
UL	5.95	0.991	4.53	0.79	-1.425	-23.931	-2.269	6.098	99.997
SL	3.94	0.243	3.50	0.148	-0.441	-11.184	-4.234	9.959	100.000

X – mean values in sec., S – standard deviation, d – mean differences (degrees of freedom), t – t-criteria of Student

For the stable leg starting mean time was 3.94 ± 0.24 s, about 2 seconds faster than the unstable leg. At the 8th practicing week, there was very slight increasing in the speed 3.5 ± 0.15 s, but enough for a statistically significant difference (α < 0.05) (Table 6, Graphic 5).

From the given results it is obvious that the performance of the hop test with the healthy leg was faster for the tested period, even though the starting mean time (3.94 s) was lower than the mean time (4.53 s) given from the unstable leg at the 8th week of the proprioceptive program (graphic 5).

Graphic 5. Statistical results of Single Leg Hop for time



*St. Significance between the 1st and 2nd measurement

Discussion

The static balance test, when performed with eyes open, was performed close to the norm, both with the stable and unstable leg. This was seen mainly after the proprioceptive training. Before it, the individuals had some difficulties maintaining quiet balance with the unstable leg, which has been overcome after 8 weeks of practicing. When the visual input was eliminated the abilities to maintain unilateral stance diminished and patients with CAI showed poor balance both with the stable and unstable leg. After the proprioceptive training they manage to increase the balance time, but still 10 seconds away from the norm with the unstable leg and 5 seconds below the norm for the stable one. That finding confirms the statement of the Stork test that with the elimination of the vision the proprioception is provoked more. And the patients from our investigation showed a bigger deficit in proprioception while standing on one leg with eyes closed, which improved in the time after the 8-week proprioceptive training, but not enough to reach the norm. Nevertheless, it seems that proprioceptive exercises, performed systematically, help to improve the static balance in patients with CAI. Sazdova (2019), in her study, shows similar results while performing One Leg Standing test with eyes closed on healthy subjects. After 4 weeks of proprioceptive specific training, they improved their static balance abilities, while performing a quite unilateral stance.

In general, the unstable ankle limb showed diminished dynamic postural control. But the dynamic balance improved after the proprioceptive training, confirmed by the improvement in touch distance in all directions of Star Excursion Balance Test (SEBT), performed from the unstable and stable leg. Similar results showed Hale et al (2007), in their study, the patients with CAI demonstrated deficits in postural control and SEBT reach tasks of the involved limb compared to the uninvolved limb, and after rehabilitation of 4 weeks they had greater SEBT reach improvements on the involved limb.

The results from the SEBT in our study showed that the most difficult task for the subjects with CAI was the Anterolateral direction (AL), as well as Lateral (L) and Anterior (A) directions, and that for both legs. These touch distances were difficult at the start of the investigation and so after the 8 weeks of proprioception training, but interestingly that exactly these 3 directions improve the touch length the most. And even in A and AL directions the differences between the legs were not significant, showing that task performance of the unstable ankle limb was equalizing with an opposite healthy one. It looks like that, not only the chronic ankle instability is the condition, that makes it difficult to control dynamic balance, while the free limb is moving in a lateral, anterior direction and the combination of them. But in general, the A, AL, and L directions are the hardest directions to perform. No matter so, the proprioceptive training helps to improve control and performance. Exactly the opposite directions Posteromedial (PM), Medial (M) and Posterior (P) directions showed an easy task performance, for both legs, but more steady for the stable ankle limb. The highest difference between leg performance, and that was statistically supported, was in the Posterolateral (PL) direction. This high divergence was before the start of proprioceptive training and remained the same after the exercising, no matter that when comparing for the leg itself, there was a slight improvement. Seems that when performing in the PL direction the lateral ankle constraints for the unstable leg were not working the same manner as in the stable leg and consequently the proprioceptive deficit in this direction is more obvious than in the other directions. Similar findings of A and PL directions were found in previous researchers, who stated that patients with CAI had significantly less reach distance and had poor dynamic postural control performance, compared to copers and healthy subjects. Though, they used the Y balance test (Jaber et al, 2018). In contrast to our study, where we did not find any importance between performances in PM direction, Hertel et al, (2006), reported that the PM component of the SEBT is highly representative of the performance of all 8 components of the test in limbs with and without CAI. Other group of authors measuring only in the PM direction of SEBT did not find statistical significance of touch distance between patients with CAI, copers, and healthy subjects (Pozzi et al, 2015). Researchers, who compared the effect of 6 weeks training of vibration program to non-vibration program, on patients with CAI, figured out improvement in M and PL directions of the SEBT for the vibrant group and M, PM and PL improvement in SEBT performance for the non-vibrant group (Sierra-Guzman et al, 2018).

Many individuals with CAI continue with more skillful sports activities like running and jumping, which was the reason to see if with proprioceptive training the symptoms of instability will decrease during more specific tasks. From the results of the One Leg Hop test for time is seen that the time of performance using the unstable leg improved, but not enough to match the time of the stable leg. Even though it is subjective, a big percentage of the patients also self-reported feeling fear of possible ankle sprain, while performing the test at the 4th practicing week, and still at the end of 8th practicing week. It is obvious that proprioceptive training helps to improve the performance during more demanding functional and sports specific tasks in patients with CAI. Definitely more neuro-muscular control is needed to be built, to reach the self-confidence and the performance of the healthy limb. We admit as one possible reason for having poor neuromuscular control during the more demanding functional tasks is relatively the short period of practicing the functional and plyometric exercises. Probably to obtain a good level of sports-specific activities, more prolonged and systematic complex proprioceptive training is needed. Some authors, besides the postural control, measured also the muscle activity around the ankle and hip joint. They pointed out that there was later muscle activation of the patients with CAI, compared with copers and healthy subjects. Therefore, the attention should be focused on conditioning the fast ankle and hip muscle activation as well (Jaber et al, 2018; Pozzi et al, 2015; Van Dun et al, 2007).

Conclusion

The results of our study support the idea that patients with CAI have diminished static and dynamic postural control, as well as disturbing functional performance while jumping on the unstable leg. During the quite unilateral balance test, the patients showed difficulties to maintain equilibrium with the affected leg, especially when the visual input was eliminated. The dynamic postural balance, measured by SEBT, also showed shorter touch distances for the unstable ankle in all 8 directions. The shortest touch distance was in AL direction, while with more than 10 cm differences compared with stable ankle was in PL, L, and A direction. The 8-week proprioceptive training improved both the static and dynamic unilateral balance of patients with unilateral chronic ankle instability. Compared to the stable limb, however, the unstable ankle still had some difficulties in performing dynamic balance tasks. This was mainly seen in SEBT with shortest tap distance again in AL direction, and the biggest discrepancies between limbs, in PL and L directions. The highest improvement in tap distance for the unstable ankle was in the A direction. Before initiation with the proprioceptive program the functional test, One Leg Hop for time, was presented slower with the chronically unstable ankle. There was an improvement in the time for hopping with the affected leg, but still a difference between the limbs remained after the training period, also with some precautious while performing the hops. Nevertheless, proprioceptive training should be irreplaceable part of the physical activity of people with chronic ankle instability.

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