The Effect of Structural Integration on Ankle Joint Position Sense and Balance

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Abstract

Structural integration (SI) is a manual therapy created by Ida Rolf that focuses on whole body functionality. The mechanisms and effectiveness of the treatment are still not well known but may be connected to fascia. PURPOSE: To determine if SI could affect ankle joint position sense (JPS) and balance in recreational soccer players. METHODS: Twenty subjects were randomly assigned into two groups; the treatment group underwent 10 SI sessions and the control group had no treatment. Pre-, 5-week, and post-intervention measurements included ankle JPS and balance assessment. JPS was evaluated with an iPod application to measure joint replication error of three angles within dorsiflexion and plantarflexion. Balance was evaluated with center of pressure (COP) excursion, in the x and y directions, as measured by a force platform during single-leg balance tests. RESULTS: At time of submission, only pre- and 5-week measurements were completed. There was a significant effect of angle ($p<0.01$) on JPS error, but group ($p=0.065$) and time ($p=0.713$) interactions with angle were not significant. Even so, JPS error reduced in the treatment group from 3.62±2.89° to 3.32±1.62° at 70° plantarflexion, from 3.26±1.70° to 2.69±2.04° at 90° dorsiflexion, and from 2.96±2.30° to 2.29±0.41° at 100° dorsiflexion. The control group reduced error at 100° from 2.01±2.05° to 1.63±1.09°, but increased at 70° from 4.05±1.96° to 4.67±1.85° and 90° from 3.37±1.48° to 3.70±2.09°. For balance, there was a significant interaction between condition and time on COP excursion in the x ($p=0.006$) and y ($p=0.035$) directions. Excursion reduced from pre- to 5-week testing across all conditions. The effect of group on x ($p=0.677$) and y ($p=0.363$) COP excursion was not significant. CONCLUSIONS: The balance changes appear to be a learning effect in both groups; after 5 weeks, both improved significantly. JPS error improved in the treatment group, but not significantly.

Introduction

SI is a form of treatment that has recently grown in popularity but mechanisms and effectiveness are not well known. The few studies completed on SI found it to improve joint range of motion, pain, and symptoms associated with muscular dystonia of the eye (Findley, Chaudhry, Stecco, & Roman, 2012; James, Castaneda, Miller, & Findley, 2009).

Possibly underlying the effects of SI is fascia, which is largely affected by tension and innervated with mechanoreceptors (Schleip, 2003; van der Wal, 2009). The mechanoreceptors facilitate the sense of touch, the sense of joint position, and proprioceptive sensations involving muscle length (Kandel et al., 2000). Mechanoreceptors are found in connective tissue, such as fascia, that is located in the body surrounding muscles, groups of muscles, blood vessels, and nerves. (Findley et al., 2012; Langevin & Huijing, 2009; Schleip, 2003; Yahia, Rhalmi, Newman, & Isler, 1992). With the stimulation of mechanoreceptors, such as prolonged pressure during SI, changes in local fluid dynamics and tissue metabolism as well as global muscle relaxation can occur (Schleip, 2003). With fascia around other structures such as muscles and nerves, changes in the fascia may affect their functionality, as demonstrated through JPS and balance. JPS has yet to be analyzed in SI studies and balance has only been assessed in one study (Findley, 2007).

The effects of other myofascial manipulation methods, such as self-myofascial release and massage, have been examined more thoroughly than SI. In a recent review, myofascial release techniques were demonstrated to be an effective way to restore or enhance range of motion in various joints without a reduction in muscle activity or performance (Mauntel, Clark, & Padua, 2014).

The ankle is the most commonly injured part of the body with ankle sprains accounting for greater than 80% of injuries in soccer (Fong, Hong, Chan, Yung, & Chan, 2007). The ability to balance greatly depends on the ankle and JPS failure can result in ankle injury (Hertel, 2002). Research is needed on the effect of SI on balance and ankle JPS. If SI can affect one or both of these parameters, future preventative care for or rehabilitation from ankle injury could improve, leading to positive implications for soccer players and other athletes. Therefore, the purpose of this study was to determine if SI significantly affected JPS or balance in recreational soccer players.

Materials & Methods

Design of the Study: This study was a repeated measures randomized groups experimental design. There were two groups, a treatment group that underwent SI and a control group that had no treatment. Pre-, 5-week, and post-intervention measurements included ankle JPS and balance assessment. This study was approved by the university Human Subjects Review Committee.

Subjects: Twenty subjects (10 female, 10 male), aged 22-40 (29±4.8) years old, volunteered to participate in this study. All were currently participating in a recreational soccer league at least once a week and had not experienced an ankle injury in the past six months.

Instrumentation: The treatment group underwent 10 total SI sessions, consisting of one per week, lasting 10 weeks. Measurements were made at baseline, within 24-72 hours of the 5th treatment and then within 24-72 hours of the end of the 10-week interval. JPS was assessed with an iPod application to measure joint replication error of three angles within dorsiflexion and plantarflexion. Balance was evaluated with COP excursion, in the mediolateral and anteroposterior directions, as calculated via force platform data during four conditions of a single-leg balance test.

Procedures:

- Subjects had a warm-up consisting of five minutes on cycle ergometer at self-selected pace followed by dynamic stretches.
- JPS data collection occurred first; the iPod was strapped to the lateral side of the subject's dominant foot and secured via a neoprene sleeve with hook and loop fasteners. The subject was then asked to go through various positions of the foot as directed by the software (70°, 90°, and 100°). These are with respect to vertical being 0°, so 90° was neutral, 70° was 20° of plantarflexion, and 100° was 10° of dorsiflexion.
- The accuracy of the reproduction of each joint angle was calculated by LabView software as the difference between the target and reproduced angles (absolute error).
- The balance assessment was carried out on an AMTI (Advanced Mechanical Technology, Inc., Watertown, Massachusetts, USA) OR6-6 force platform collecting at 1200 Hz. Both dominant and non-dominant foot were used in both eyes open (EO) and eyes closed (EC) conditions.
- The subject performed each condition 3 times for 10 seconds in a randomized order. Stopping codes were used for consistent form between subjects (Springer, Marin, Cyhan, Roberts, & Gill, 2007) and 5 seconds of balancing was required per condition.
- After collection, BioAnalysis with NetForce by AMTI was used to export the data and then analysis was done with Excel. The standard deviation of the COP, in the anteroposterior and mediolateral directions, was analyzed to represent COP excursion over the 5-s testing period for each subject.

Data Analysis: Mean and standard deviations were calculated using Excel. Statistical analysis was done using a 2-way mixed ANOVA for absolute error and COP excursion with SPSS version 21 (IBM Corp., Armonk, New York, USA). The ANOVA was performed to look for an interaction between the group (treatment vs. no treatment) and time (pre, mid, and post) over the experiment as indicated for ankle JPS absolute error and single-leg COP excursion measurements. Specifically, differences between pre, mid, and post mean absolute error as well as COP excursion in the mediolateral and anteroposterior directions were evaluated. If an interaction was identified, simple effects were analyzed as well. Alpha level was set to 0.05.

Results

- At time of abstract submission, only pre- and 5-week measurements were completed.
- The results did not support the experimental hypothesis for JPS; there was a significant effect of angle ($p < 0.01$) on JPS error, but group ($p = 0.065$) and time ($p = 0.713$) interactions with angle were not significant (Figures 1-3).
- The results also did not support the experimental hypothesis for balance between groups but there was a significant interaction between condition and time on COP excursion in the mediolateral ($p = 0.006$) and anteroposterior ($p = 0.035$) directions. Excursion reduced from pre- to 5-week testing across all conditions (Figure 4).

	70º (20° PF)		90º (Neutral)		100º (10° DF)	
Time	Tx	No Tx	Tx	No Tx	Tx	No Tx
Pre	3.62±0.96	4.05±0.62	3.62±0.57	3.37±0.47	2.96±0.77	2.01±0.65
Mid	3.32±0.54	4.67±0.59	2.69±0.68	3.70±0.66	2.29±0.14	1.63±0.34

Table 1. Joint replication error (°) mean ± standard error of the mean for each group over time across each angle tested. PF=plantarflexion; DF=dorsiflexion

	Eyes closed left		Eyes closed right	
Time	Tx	No Tx	Tx	No Tx
Pre	0.055±0.009	0.068±0.010	0.047±0.009	0.068±0.017
Mid	0.011±0.004	0.006±0.001	0.011±0.004	0.005±0.001
	Eyes open left		Eyes open right	
Time	Tx	No Tx	Tx	No Tx
Pre	0.025±0.004	0.027±0.001	0.030±0.006	0.026±0.002
Mid	0.005±0.002	0.003±0.000	0.006±0.003	0.003±0.000

Table 2. COP_x excursion mean ± standard error of the mean (m) for each group across the four balance conditions.

	Eyes closed left		Eyes closed right	
Time	Tx	No Tx	Tx	No Tx
Pre	0.094±0.023	0.106±0.017	0.080±0.017	0.173±0.063
Mid	0.022±0.011	0.011±0.002	0.016±0.005	0.011±0.001
	Eyes open left		Eyes open right	
Time	Tx	No Tx	Tx	No Tx
Pre	0.050±0.010	0.049±0.007	0.040±0.007	0.052±0.007
Mid	0.008±0.002	0.005±0.001	0.011±0.004	0.005±0.001

Table 3. COP_y excursion mean ± standard error of the mean (m) for each group across the four balance conditions.

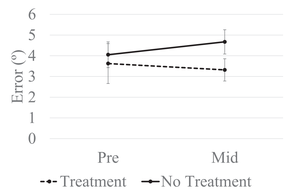

Figure 1: A graphical representation of each groups joint replication error over time for the 70° (20° plantarflexion) angle.

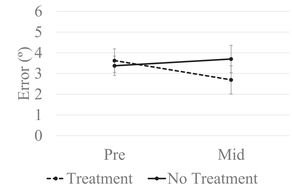

Figure 2: A graphical representation of each groups joint replication error over time for the 90° (neutral, 0° dorsiflexion) angle.

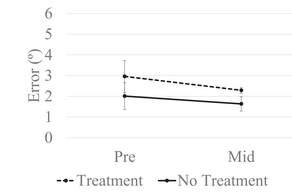

Figure 3: A graphical representation of each groups joint replication error over time for the 100° (10° dorsiflexion) angle.

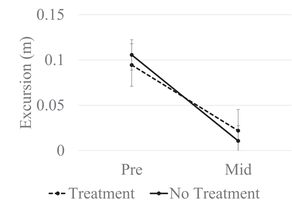

Figure 4: A graphical representation of each groups COP_x excursion over time for the eyes closed left balance condition.

Summary & Conclusions

The results showed both groups significantly decreased their COP excursion in the mediolateral and anteroposterior directions across all single-leg balance conditions over time. This finding may suggest that the improvements were the result of a learning effect. Improvement in COP excursion, however, may have affected the soccer player's ability to perform during gameplay. It was hypothesized by Barone et al. (2010) that proprioceptive training of both legs resulting in improved one-leg standing balance could maximize kicking performance due to the amount of time spent on one leg when striking, passing, or trapping the ball.

JPS, as evaluated by joint replication error, did not significantly improve over time. Range of motion was not measured in this study but it was noticeable that the range of motion varied across the subjects. Those with more range of motion would have more opportunity for error. SI has been demonstrated to improve range of motion in the past (James et al., 2009), so the treatment subjects may have experienced an increase range of motion over time, maintaining greater error than the control group, minimizing improvement. Additionally the participants varied greatly in JPS ability resulting in large standard deviations; this may have affected the significance for both JPS and balance.

Overall, the balance changes appear to be a learning effect in both groups; after 5 weeks, both improved significantly. JPS error improved in the treatment group, but not significantly. It is possible that five weeks of SI fascial manipulation is not enough time for significant changes between groups.

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