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RESEARCH ARTICLE

Differences in Proprioceptive Balance between High School Varsity Athletes and High School Non-athletes

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Abstract

Proprioceptive skill is an important component of everyday activity and optimal athletic performance. Additionally, proprioceptive training reduces initial and recurrent injury risk. However, despite the rise in adolescent athletic injuries, no peer-reviewed case-controlled studies exist comparing proprioceptive ability in high school athletes. This study examined the extent that proprioceptive skill differed between high school varsity track athletes (n=20) and high school non-athletes (n=20), using the previously validated single-legged stance (SLS). No differences existed between groups in gender, age, BMI, blood pressure or heart rate. There were statistically significant mean differences in SLS time between the athletes and the non-athletes on both the right (*Mdiff = 7.452, p = 0.007)* and left lower limb (*Mdiff = 8.517, p = 0.001).* Specifically, high school athletes demonstrated greater proprioceptive balance skills as compared to high school non-athletes at baseline, highlighting the importance of proprioceptive training in adolescent athletics.

1. Introduction

Musculoskeletal injuries are increasingly prevalent in pediatric and adolescent populations as participation in athletic activities continues to rise (1-2). In these age groups, susceptibility to injury becomes inherently greater if ongoing physical maturation and development is not accompanied by concomitant improvement in coordination and balance. Thus, proprioception–the sensory perception of bodily position and movement, an intrinsic component of balance–is a central tenet of optimal athletic performance and injury prevention.

Research consistently demonstrates the effectiveness of balance and proprioceptive training in reducing injury risk and optimizing functional performance for school-aged children and adults (3-7). Mechanistically, this field highlights the ongoing feedback system through which visual, vestibular and proprioceptive inputs contribute to well-calibrated motor output (6). Conversely, in the setting of an injury, disrupted mechanoreceptor signaling–i.e., proprioceptive afferents– from within joints, or other tissues such as tendons or ligaments, leads to reduced position sense and increased risk of injury recurrence (8,9). However, this research is typically centered in post-injury rehabilitation,(10-11) and studies comparing school-aged athletes against their peers are sparse (3).

Thus, the present study seeks to evaluate differences in proprioception between athlete and non-athlete high school students. In turn, we aim to contribute to the recent swell of interest pertaining to methods to reduce injury rates in this population (12-13).

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2. Methods

2.1 Subjects

Participants consisted of 40 high school students, split evenly between comparison groups of varsity track athletes (n=20) and students not affiliated with a school athletic team (n=20). Inclusion criteria for all participants were: age between 15-18 years old, Body Mass Index (BMI) of 18.5-24.9 kg/m², heart rate (HR) between 60-100 beats per minute, and blood pressure (BP) of 120/80±10 mm Hg; these BMI, HR, and BP values are established as normal limits within this age group. Exclusion criteria included participants who had been formally diagnosed with a musculoskeletal injury in the preceding four weeks or had self-reported musculoskeletal symptoms such as pain, weakness, or stiffness. Written informed consent was obtained from all interested participants prior to enrollment in the study. All physical health identifiers and demographic data were kept confidential.

2.2 Performance Outcome Measures

The primary outcome of the study was the difference in proprioception between the two groups as measured by the mean time participants could hold the Single Leg Stance (SLS) on their right and left legs. The SLS is a validated clinical test of proprioceptive balance (6). Consistent with established protocols, participants in the present study were instructed to place their arms across their chest, stand on one leg, raise their contralateral leg to the mid-calf, and then close their eyes.

The timer began once both eyelids were closed. Participants were timed for a maximum of 30 seconds. After participants either a) reached 30 seconds or b) touched their elevated leg to the ground, the clock was stopped. Participants then performed the same task on the opposite leg. Once finished on the contralateral side, participants were provided with a one minute break. Performing the task once on each leg represented one trial. In total, three trials were performed, and mean data were calculated for recordings on each attempt on their right and left legs.

2.3 Analysis

Statistical analyses were completed using Excel Data Analysis. Descriptive statistics are reported for all variables. Independent t-tests were used to determine if there were any statistically significant differences between the athlete and non-athlete groups in baseline demographic data, including potential confounding variables of BMI, blood pressure, and heart rate. Independent t-tests were also used to determine if statistically significant differences existed between groups for the time in seconds that the SLS was performed on each limb.

2.4 Statistical Analysis

The sample size for this study was determined using G-Power which provided an estimate of 40 participants. An independent t-test analysis with a 0.5 effect size, as well as F-test statistics were performed on the mean data for Groups A and B. A P-value below 0.05 was considered significant.

3. Results

Independent t-tests revealed no differences in gender, age, BMI, blood pressure, or heart rate between the two groups (Table 1). Statistically significant differences in proprioceptive balance training, as measured by the SLS, existed between groups for both the right (*Mdiff = 7.452, p = 0.007)* and left (*Mdiff = 8.517, p = 0.001)* leg (Table 2, Figure 1). Specifically, varsity athletes performed the SLS significantly longer on both their right and left leg when compared to non-athletes.

Table 1. *Demographic characteristics of participants*

Characteristic	Athletes	Non-Athletes	p-value
Age (Mean ± SD)	16.20±0.69	16.55±0.51	0.7833
BMI	20.37±3.16	21.45±3.17	0.2737
Sex (n. %)			
Female	10	10	
Male	10	10	
Systolic Blood Pressure (mmHg)	115.95±15.23	110.45±14.41	0.2645
Diastolic Blood Pressure (mmHg)	75.25±12.34	71.8±11.60	0.3687
Heart Rate (BPM)	76.65±8.67	82.45±12.73	0.1131

Table 2. *Proprioceptive balance training results*

Cohort	Athletes	Non-Athletes	p-value
Right Limb (s)	25.70±7.40	17.33±10.27	*0.007
Left Limb (s)	25.45±8.42	16.95±9.60	*0.001
Average trial time (s)	25.59 ± 5.04	17.34 ± 7.50	*.0008

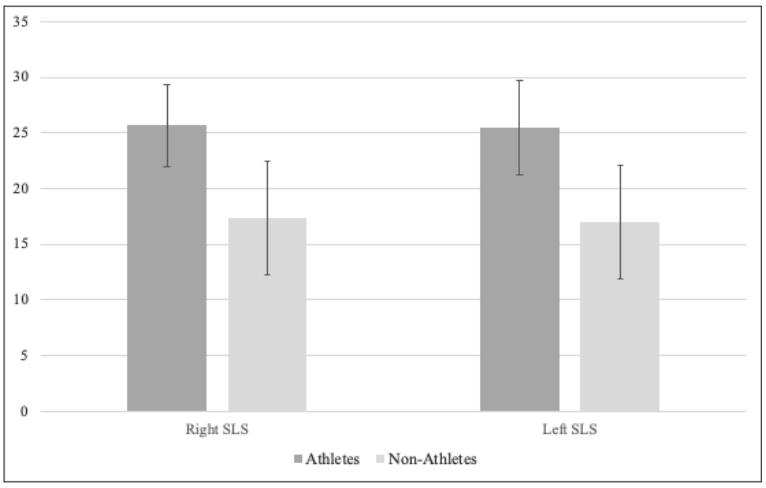

Figure 1. *Proprioceptive balance training in athletes vs. non-athletes by limb*

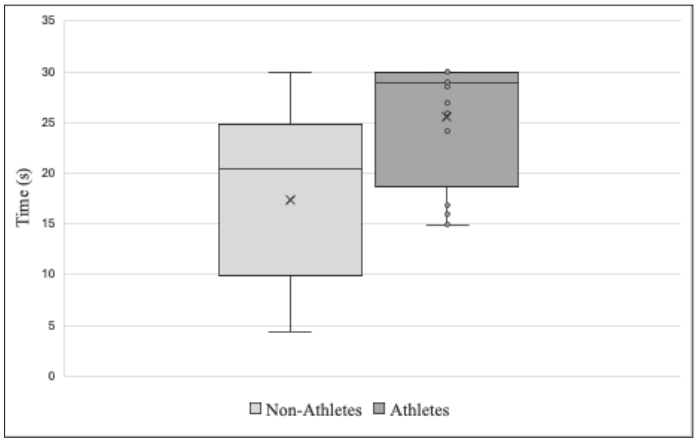

Figure 2. *Proprioceptive balance training in athletes vs. non-athletes by average time*

5. Discussion

Varsity athletes in the present study demonstrated superior proprioceptive balance compared to their non-athlete peers, as evidenced by the statistically significant difference in the average time spent by each group performing the SLS. Furthermore, the differences between cohorts were evident on trials of both the right left, left leg, and cumulative average trial time. Overall, these results are consistent with previous work, which has found superior proprioceptive skill in athletes compared to non-athletes (14). However, our work is novel in that these differences were observed in healthy high school students who had not received any formal balance or proprioceptive training, which to our knowledge has not previously been reported.

The results of this study underscore the potential of proprioception as a crucial skill in reducing injury frequency among school-aged children—athletes or not, proprioception improves until late adolescence and reaches maximal reliability and accuracy around the age of 18, and thus presents a viable and trainable target for injury prevention initiatives (15). Furthermore, a recent review and meta-analysis examining sports injury prevention in this demographic emphasized the significant benefits of incorporating balance and neuromuscular activities into warm-up routines (12). Specifically, activities such as single leg balance, either alone or combined with functional tasks like dribbling, catching, or kicking, were found to be more effective in preventing injuries compared to comprehensive programs that included aerobics or stretching exercises.

As with previous studies, we cannot conclusively determine whether the superior proprioceptive skill observed in varsity athletes is inherent or a result of their training regimes (14). Future research should focus on intervention-based studies to better establish

the degree to which a causal relationship exists and consider factors such as limb dominance, type of training, and temporal intervals . That said, given the extensive literature supporting the efficacy of proprioceptive training in injury prevention—and that demonstrating the high rates of injuries during sports and playground activities-- incorporating such training into regular physical education and sports programs for all adolescents, regardless of their athletic status, appears prudent (12).

In conclusion, this study highlights the significant differences in proprioceptive balance between high school varsity athletes and non-athletes, emphasizing the need for proprioceptive training interventions. Such training could potentially reduce injury rates and enhance overall athletic performance, promoting long-term health and wellness among adolescents. Future research should aim to elucidate the mechanism underlying these differences and develop effective strategies to integrate proprioceptive training into youth sports and physical education programs.

6. References

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