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FINAL REPORT AND REFLECTION

"WEARABLE TECHNOLOGY APPROACH TO DETERMINING EXERCISE FIDELITY IN ATHLETES DURING A NEUROMUSCULAR TRAINING WARM-UP PROGRAM"

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Introduction

Basketball is a popular high school sport across North America [1-3], but the nature of the sport often results in a high incidence of lower extremity injuries amongst youth basketball players [3-11]. Often leading into reduced physical activity into young adulthood, this can have long term negative consequences, which include an increased risk of osteoarthritis [12-14], chronic disease, and obesity [15,16]. Literature has shown, however, that regular participation in neuromuscular training (NMT) warm-up programs can reduce injury risk by 29% among youth basketball players [17-19].

Currently, adherence to NMT programs are often quantified by the frequency of sessions or the total duration of the warm-up [22]. Exercise fidelity, however, which is the correct execution of the NMT warm-up program, is not often considered when looking at adherence. Therefore, the influence of movement quality of athletes during NMT programs and their influence on injury rates is not known. Thus, this project looks to determine exercise fidelity in youth basketball players to determine how the correct execution of an NMT warm-up program contributes to the beneficial outcomes for injury prevention [23].

Quiet often, analysis of movement quality has been difficult in a real-world setting, as qualified personnel are typically needed to observe and evaluate movement patterns, which could be influenced by observer bias and is a time-consuming process [23]. Likewise, the use of traditional motion capture systems is expensive often confined to a laboratory and clinical setting, while requiring trained personal to conduct the study [24]. Recent advancements in

wearable technology has provided new means of to measure movement quality of athletes outside of the traditional laboratory setting [25]. Thus, development of a wearable-technology based system can provide information on exercise fidelity, its influence on NMT warm-up programs, and its influence on injury rates amongst youth basketball players.

The objective of this study is to use wearable technology to quantify exercise fidelity and determine the effects of exercise fidelity on injury rates among youth basketball players participating in an NMT warm-up program. The significance of this research is that it will be the first study to determine how the quality of exercise during an NMT warm-up program influences the risk of injury among youth basketball players. Specifically, this study will establish a framework for monitoring adherence to NMT warm-up exercises, which can be used to determine the effect of dosing and delivery of NMT warm-up programs, and lead to better understanding of the efficacy of NMT warm-up programs for the prevention of sports injuries.

Methods

We looked to conduct a cross-sectional study that involved the recruitment of 113 youth basketball players (Ages 14-18) from nine high schools from across Calgary who are currently partaking in an NMT warm-up program, though preliminary results show analysis for 27 players. An IMU wearable device (Shimmer3 GSR+®, Shimmer Inc., Dublin, IE) was worn by the athlete on their lower back during a practice session, with concurrent video recordings of the athletes. The Shimmer3 device consists of a 3D accelerometer (accelerations, m/s2), gyroscope (angular velocity, °/s), and magnetometer (orientation, gauss), with data being recorded at

200Hz. Athletes were asked to perform the NMT warm-up program as they normally do, which consists of exercises seen in Table 1.

Analysis of the concurrent video recordings were conduced using Dartfish software to determine distinct timing landmarks to indicate the beginning and end of each exercise, with data from the Shimmer3 wearable devices being analysed using MATLAB (MathWorks, USA) and Stata (StataCorp LP, USA).

Results

Analysis of the "Side Plank" exercise showed an 8.01% difference between Side 1 (88.15%) and Side (96.16%) of Player 1, whereas Player 2 had a 32.42% difference between Side 1 (86.43%) and Side 2 (54.01%). The "One Legged Jump Over the Line" exercise showed that Player 1 had a 17.12m/s^2 difference between the forward and backward accelerations of Leg 1, with the difference being 0.80m/s^2 in Leg 2. Player 2 had a difference of 0.08m/s^2 and 2.62m/s^2 for legs 1 and 2, respectively. The peak forward-backward acceleration for Player 1 also showed a significant difference between the two legs, with a difference of 6.16m/s^2, whereas Player two had a difference of 3.19m/s^2.

Conclusion

Preliminary results indicated that the acceleration of the Shimmer3 devices are sensitive enough to differentiate movements amongst players when performing exercises in the NMT warm-

up program. Side-to-side differences were apparent amongst athletes during the “Side Plank” and the “Single Leg Jump Over the Line” exercise. Specifically, differences seen when looking at the “Side Plank” suggests that Player one has better alignment in the medial-lateral direction compared to Player 2. Likewise, Player 1 had a higher landing peak moving forward compared to backwards, whereas Player 2 was consistent in their forward-backward movements.

Further analysis is currently in progress for other exercises in the warm-up program, as well as video analysis of the same sessions to determine exercise fidelity and its effects on injury prevention. We will also continue to analysis the gyroscope and magnetometer data to determine its sensitivity in differentiating movements during the NMT warm-up program. Likewise, this project will look to advance knowledge on how NMT warm-up programs can reduce injuries. Specifically, it will establish a framework for monitoring adherence to understand the efficacy for injury prevention in sports.

Appendix

Table 1

Types of neuromuscular training warm-up exercises performed by athletes.

Aerobic	
Forward Run	1-2 laps running forward using arms and relaxed running technique
Forward Run with Backward Zig-Zag	1-2 laps running forward followed by a backward zig-zag shuffle or carioca coming back to starting point
Skipping	1-2 laps of forward-backward or sideways skipping
Forward Run Progression	1-2 laps running forward with a progression of speed to the end
Agility	
Single Leg Jump Over a Line	10-15 reps per leg of forward-backwards or side-to-side jumping over a line with good posture and knee-over-toe position
Jumps	8-12 reps of squat or skate jumps with good knee-over-toe position
Strength	
Plank	20-30 seconds of planks on elbows or with leg lifts
Side Plank	20-30 seconds per side of side planks on elbows or with arm lifts
Hamstrings	3-10 reps of lowering body to mat while maintaining straight line
Walking Lunges	5-10 meters with torso rotation or knee lift, forward-backward
Side Lunges	2-4 reps in each direction or 8-12 reps with arm circles
Balance	
Single Leg Balance (Static)	4-6 reps per leg with torso rotation or with ball roll; completed with partner and sport-specific ball
Single Leg Balance (Dynamic)	4-6 reps per leg with ball toss or with jump catch; completed with partner and sport-specific ball

Table 2

"Single Leg Jump Over the Line" accelerations for each leg of two players

	Player 1: Leg 1	Player 1: Leg 2	Player 2: Leg 1	Player 2: Leg 2
Peak Forward-Backwards Acceleration (m/s^2)	41.08	34.92	29.23	32.42
Forward Jump Acceleration (m/s^2)	37.76 ± 2.08	30.35 ± 2.59	26.97 ± 1.02	28.93 ± 1.53
Backward Jump Acceleration (m/s^2)	20.64 ± 0.53	29.55 ± 0.54	26.89 ± 0.54	26.29 ± 0.94

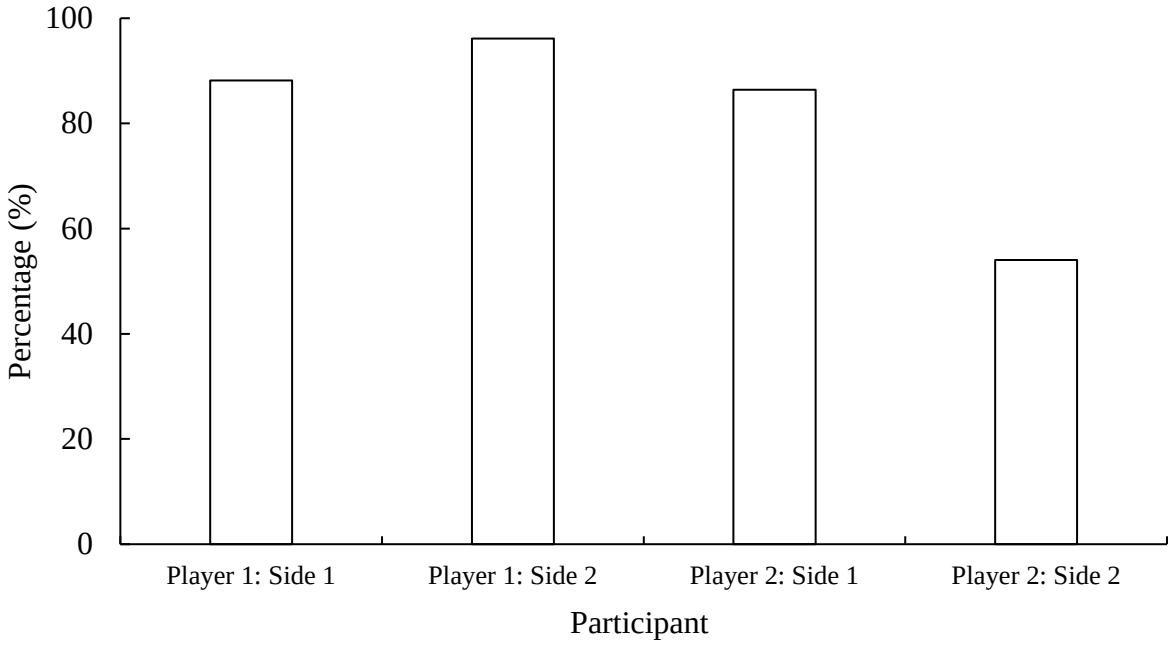

Figure 1. The percentage of gravitational acceleration in the medial-lateral direction during the "Side Plank" exercise.

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Reflection

This past summer, I had the opportunity to pursue a summer research project under the supervision of the Sports Injury Prevention Research Center, where I used wearable technology to understand the exercise fidelity of youth basketball players during a neuromuscular training (NMT) warm-up program. Undoubtedly, this has been a work-integrated learning experience that has allowed me to develop numerous skills that I believe will translate in many of my other roles, such as with the Students' Union as the Faculty of Kinesiology Representative and the Thrive Center as the Outreach Director, in addition to my future career ambitions of becoming a physician.

Specifically, I believe one of the fundamental skills that I have developed during my research experience has been communication, both with regards to public speaking through various oral and poster presentations I had the opportunity to partake in, as well as through collaboration with members of my laboratory. Specifically, within the realm of presentations, I had the opportunity to conduct four presentations to students and academia at various symposia, where I had to communicate my research in a way that could be understood by those who may not have the same background knowledge as myself in my area of research. Likewise, I was required to create a poster and PowerPoint presentation, which must be clear and concise for the audience. Translated into my other involvements, I believe the development of my communication abilities has and will continue to allow me to share my thoughts in a concise manner, specifically during my meetings through my role with the Students' Union. Looking at a potential career into medicine, the development of my communication skills will allow me to foster a better personal connection with my patients will allowing them to understand the situation.

In addition, my summer research experience also allowed me to be adaptable to the various situations and problems that I was faced with, specifically regarding working with other members of my laboratory. Because of the timing of the project spanning the summer months, many of the members of this project were often on leave to vacation, limiting communication to emails with minimal meetings. Likewise, because of a family emergency, I was forced to work on much of my project remotely from Vancouver. Though these are often scene as barriers, I felt that this was an experience that allowed me to be adaptable to changes, while allowing me to develop time management skills. The skill of being adaptable is important, not only in one's professional career but also in one's everyday life as it allows us to be innovative and resourceful while being open minded to changes. Likewise, it allows for us to learn from our mistakes, accept feedback, and cope with uncertainty which is prevalent often in research.

The pinnacle experience of my undergraduate studies at the University of Calgary has been my work as an undergraduate research for the past three summers, made possible through studentship funding such as PURE. This has inevitable been a work integrated learning experience that has allowed me to build skills, make connections, and help shape the future of my career. By the end of my undergraduate studies in April of 2020, I hope that I can continue to practice the skill of being adaptable, so that I can maintain a mindset that allows for feedback for self improvement, both personally and professionally.