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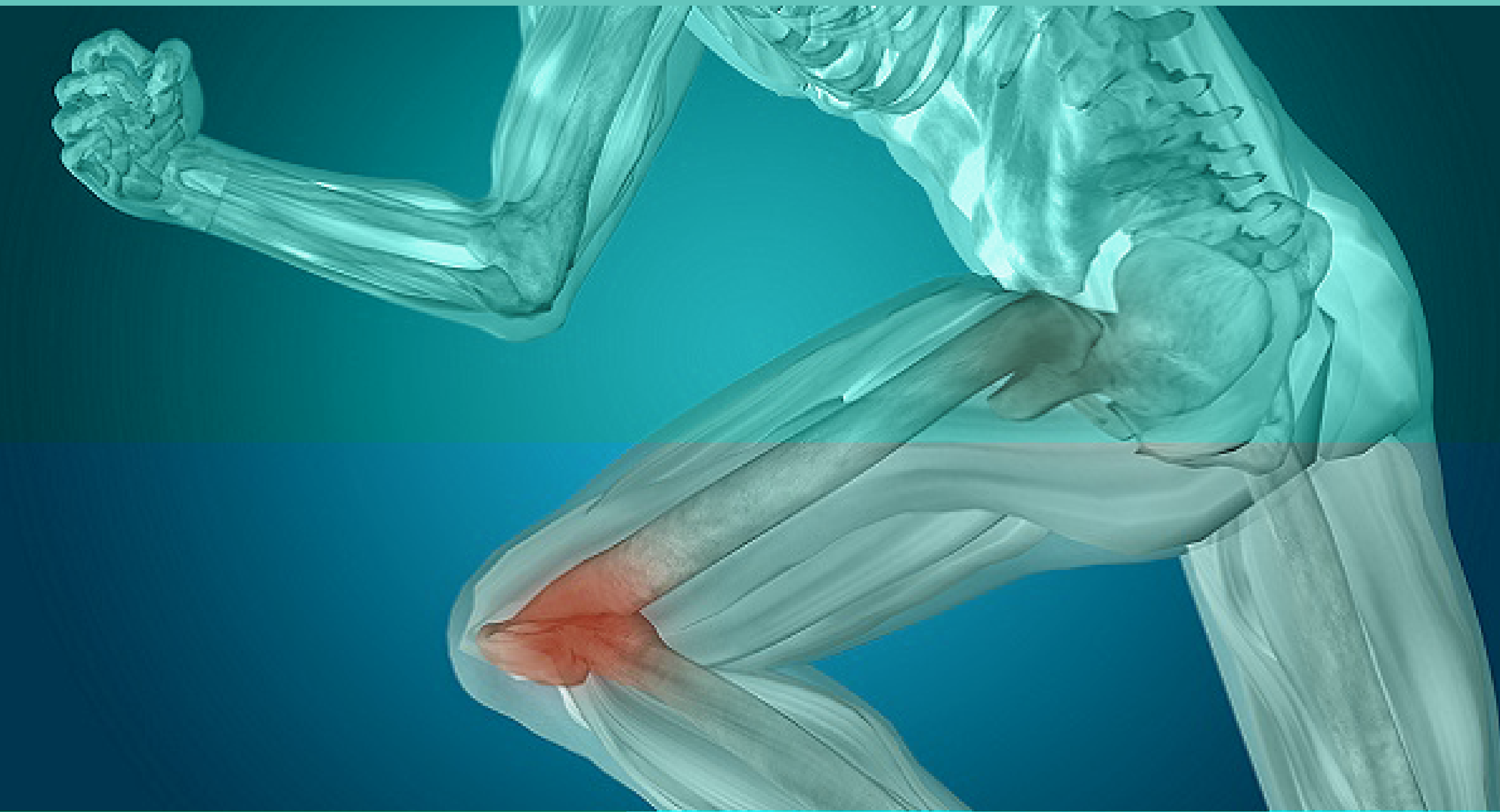

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Editorial

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The "Tactical" Athletic Trainer: Healthcare for the Military

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As a certified and state licensed clinician in the athletic training profession, I administer treatment and therapy based on my educational background. My patients are active individuals including athletes and recreational sports participants. Over my 30+ years, I've treated others such as police officers or those involved in dance and performing arts. The educational preparation and job setting, as well as responsibilities for an athletic trainer have changed greatly over the years. Once the traditional setting was mostly high schools, colleges and universities, with a small percentage employed in professional sports.

Over the years the employment settings have changed to include clinics, healthcare facilities within industry, hospitals and fitness centers, law enforcement agencies, and the military. According to the National Athletic Trainers' Association, 37% of athletic trainers are employed in secondary schools and the college/university setting. Only 2% are employed in the "emerging settings" of Performing Arts, Public Safety, Occupational Health and Military.[1] Given this emerging setting, we need to provide a viable educational curriculum to support the emergence of the "tactical athletic trainer."

The Tactical Athletic Trainer

The purpose of this editorial is to discuss the "tactical athletic trainer" as well as propose a new way of thinking about how we should educate this person for the emerging job market with the military and law-enforcement. First, some background: The emergence of the "Tactical" athletic trainer may not be new to some, but the importance of this relatively new healthcare provider cannot be more important, than to those serving in the military who have benefited by their care. According to the Merriam-Webster dictionary, the definition of the term "tactical" is or relating to tactics or relating to small-scale actions serving a larger purpose, planning or maneuvering to accomplish a purpose.[2] If used as an adjective to "relating to," or constituting actions carefully planned to gain a specific military end, it ideally identifies the role of the tactical athletic trainer in a supporting role for carrying out the mission of providing specific healthcare techniques to achieve the objective of providing therapy or conditioning to injured members of our military. The athletic trainers' educational preparation has always included the prevention, care and treatment of injuries to active populations, the military would fit into that category. Soldiers will encounter daily activities of running, strength training and conditioning to accomplish their basic training as well as maintaining physical fitness for possible deployment to a combat area. In a historical perspective, ancient games and activities were developed into sporting events to keep early Greeks and Roman soldiers in shape, many of the "early" athletic trainers in those times worked on soldiers/athletes to keep them injury free. Athletic Trainers are ideally prepared to treat not only patients who are athletes but to also treat patients who serve in our nation's military. Many of the injuries seen in basic training involve lower extremity injuries and the tactical athletic trainer is well suited to be employed. The same strategies we use in the athletic training clinic to assist patients/athletes to return to play, can be applied to our active military members.

Using this concept, any branch of the military could employ a certified athletic trainer to provide a wide range of healthcare delivery that is carefully "planned to gain a specific military end" such as ensuring our military are in the best possible shape to perform each their

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objective. It is my opinion that the athletic training profession needs the flexibility to adapt to the needs of the growing demand for tactical athletic trainers. Constant changes in healthcare will force the profession to make changes to the education of the entry-level athletic trainer, thus providing more opportunities to expand our presence in the healthcare market.

Current Status of Tactical Athletic Trainers

A few programs exist at some military bases today, to ensure that recruits, soldiers and their dependents receive the best possible healthcare. The job they do for our military include providing musculoskeletal injury care, injury prevention and Human Performance Optimization functions as well as limited patient care. Additional duties would include triage evaluations for patients with acute injuries and organizing and conducting medically prescribed rehabilitation and conditioning programs. For example new recruits need to be evaluated by the tactical athletic trainer to determine how susceptible they are to injuries. Sometimes identified as "musculoskeletal specialist," these athletic trainers have been instrumental in educating soldiers on how to prevent injuries as well as provide therapy to reduce recovery time from injuries. These tactical athletic trainers are the first line to providing musculoskeletal care to soldiers during training and provide guidance on diet and nutrition as well as exercise.[3] As in all healthcare providers, it's important for the clinician to possess the ability to assess and diagnosis a variety of conditions (injuries & illnesses), while also determining risk factors, prevention strategies as well as selection of the proper therapeutic modalities or exercise. The skill set needed for this tactical athletic trainer should include more than those that are basic to the education of the entry-level athletic trainer. Currently, the education of the entry-level athletic trainer incudes advance first-aid techniques, triage management skills, evaluation and diagnosis of musculoskeletal injuries and general medical conditions, therapeutic modalities and exercise techniques, nutrition, knowledge of pharmaceuticals and lastly administrative techniques. A majority of this curriculum is already in place at every institutional that houses an athletic training curriculum that meets the standards of the Commission on Accreditation of Athletic Training Education (CAATE) programs.[4] The challenge is to meet all the requirements set forth by the CAATE, as well as including additional courses in advanced exercise physiology, strength and condition techniques. Those institutions that can meet the challenge and assign dedicated faculty to the additional courses will produce a highly trained athletic trainer. In addition to the student seeking Board of Certification (BOC) as an athletic trainer, the curriculum should include specialized course work in the afore mentioned areas of advanced exercise physiology, strength and conditioning techniques as well as seeking additional certification through the National Strength & Conditioning Association (NSCA). Another thought, is to have your entry-level athletic trainers earn a master's degree in exercise physiology. With changes proposed by the CAATE, in 2022 the bachelor's degree for entry-level athletic training will be replaced with the master's degree being required by the BOC to sit for the national exam. Perhaps, we as educators considering the master's entry-level preparation should encourage students to earn a bachelor's in exercise physiology. This would allow an individual to sit for both the BOC exam and the CSCS exam. Once completed and with these two certifications in hand, the individual would be qualified to be employed as a tactical athletic trainer employed directly with the military or as a Department of Defense sub-contractor (healthcare provider group) serving our military.

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Editorial

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Body Composition: A Necessary Tool in Individuals With Disabilities?

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The 2016 Summer Olympics, also known as the Games of the 31st Olympiad concluded last month with the 2016 Paralympics set to begin in early September. Advancements in training techniques, clothing and footwear continue to contribute to the establishment of new records at the Summer Olympics. Likewise, advancements have been made for Paralympic athletes in both prosthetics- and wheelchairs. However, a key factor in the performance of all athletes is body composition, but the development of accurate field methods for measuring body composition for disabled athletes lags behind comparable measures for able-bodied athletes.

Body composition is a primary component of physical fitness[1] and individuals with disabilities are faced with an even greater amount of imposed sedentary time than their able-bodied counterparts. A physical disability that results in the individual using a wheelchair is associated with changes in body composition, specifically in the lower limb area. These changes can be due to immobilization and decreased movement and activity levels[2] and must be taken into consideration when assessing factors such as fat mass (FM), fat-free mass (FFM), body density (BD) and percentage of body fat (%BF) within disabled populations.[3-5] Hydrostatic weighing can be awkward for paraplegics, therefore, anthropometry (skinfolds, circumferences, and diameters), which was developed in normal populations, has been viewed as an alternative. But body composition differences such as the loss of lean tissue in the lower extremities, changes in bone mineral density, and fluid shifts affect the primary assumptions made regarding density of mineral, protein, and fat when converting body density to percent body fat.[6] The unusual upper body development of the paraplegic athlete and the decreased bone mineral density in the lower limbs result in an underestimation of fat mass in these subjects.[7]

The most common field testing methods of body composition in individuals with disabilities are body mass index (BMI),[8] skinfolds,[6] and bioelectrical impedance analysis.[4] BMI can be calculated quickly from measured or reported height and weight (kg/m^2) and has been used as a measure of adiposity to predict disease risk, including in patients with a spinal cord injury (SCI).[9,10] Body weight comprises lean tissue, fat tissue and bone mass; so, if BMI is the only measure, adiposity may not be accurately identified. However, Jones, Legge and Goulding,[8] determined that many individuals with SCI do not appear obese, have a healthy BMI, yet, carry large amounts of fat tissue as determined by dual-energy x-ray absorptiometry (DXA). This finding supports the need to develop reliable field methods of determining FM and FFM in individuals with disabilities

Bioelectrical impedance analysis (BIA) is a simple, non-invasive procedure that has been widely used in clinical settings to estimate total body water and fat free mass of able-bodied populations. It measures the impedance to the flow of a low-level electrical current throughout the body. This measurement assumes that the impedance within the tissues will be constant for all body segments. However, SCI-related changes in the lower body, may alter the tissue impedance due to changes in protein and mineral content of the paralyzed extremities. Measurement of the impedance of body segments may provide more accurate information.[11,12]

Given the limitations of current field testing, it is imperative that researchers further refine body composition testing for disabled athletes. The development of reference measures to accurately quantify the constituents of the fat free body in the wheelchair population might be a place to start. Kocina[4] suggests using laboratory-based methods such as hydrometry for to-

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tal body water, DXA for bone mineral content, bone mineral density and lean tissue mass to establish the reference measures. Then, skinfold and BIA equations may be developed to accurately estimate body composition. However, the continued challenge will be the varying degrees of impairment with those with SCI or paraplegia from other causes.

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A Comparison of the Degree of Perceived Exertion by Participants In Nordic Walking and Level Walking at Equal Levels of Relative Exercise Intensity

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ABSTRACT

It has been reported that the perceived exertion in level walking (LW) is the same with or lower than that of nordic walking (NW), although the exercise intensity of NW is higher than LW. Based on this fact, it could be expected that absolute intensity, the speed, should differ if the relative intensity, measured using VO_2 level, is the same in both types of walking. This study aimed to clarify the levels of perceived exertion between NW and LW when their VO_2 levels are equivalent. The subjects were eight healthy young males who exercise regularly. They performed three tests: an incremental test to obtain their regression formula between theVO_{2max} and the speed, the submaximal exercise test of NW (the NW condition) at 40% of each subject's VO_{2max} speed, and LW test (the LW condition) at the speed we substituted the value of VO_2 provided in the NW condition into the regression formula. They conducted a six-minute exercise in each condition. Measurements included percentage of VO_2, heart rate reserve (%HRR), and perceived exertion (OMNI scale) of their upper limbs, lower limbs, and whole body. Although there was no significant difference in VO_2 and %HRR, there was in speed, with the subjects walking faster in the LW condition (p<0.01). No significant difference was found between the conditions on the OMNI scale of their whole body and lower limbs, but the NW condition produced significantly higher values than the LW condition for their upper limbs (p<0.01). The results suggested that the same exercise intensity can be obtained at a slower speed in NW, and higher exertion was perceived only in their arms in NW, with no difference in their lower limbs or whole body.

KEYWORDS: Nordic walking; Relative intensity; Perceived exertion; OMNI scale.

ABBREVIATIONS: NW: Nordic walking; LW: Level walking; SE: Standard error; VO_{2max}: Maximal oxygen uptake; VO_2: Oxygen uptake; HR: Heart rate; %HRR: Heart rate reserve; ECG: Electrocardiogram; ANOVA: Analysis of variance; HR_{max}: Maximal heart rate.

INTRODUCTION

The modern health boom has caused Nordic walking (NW) to become increasingly popular as a form of exercise in and around northern Europe. NW is a walking style that developed from summer time cross-country ski training and requires two ski poles.[1]

Many studies have reported that a difference between NW and normal level walk-

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ing (LW) is the energy expenditure involved.[2-7]; when NW and LW are conducted at a certain speed, oxygen uptake (VO_2) and heart rate (HR) are higher in NW. The researchers conducting these studies concluded that the reason for this difference is that NW involves many muscles of the upper limbs.[4,5,8] On the other hand, some researchers have reported that VO_2 and HR increased in NW but perceived exertion did not. Figard-Fabre et al[9] studied obese middle-aged women and found that perceived exertion was lower in NW than in LW at the same speed. In view of these results, we could regard NW as a suitable exercise style for health promotion, since it appears to offer higher exercise intensity with comparable or less perceived exertion relative to LW.

Nevertheless, it can hardly be assumed that NW would benefit everyone, as the exercise intensity of NW exceeds that of LW when the walker moves at the same speed. Higher exercise intensity would mean greater difficulty in performing the exercise for people who have a low physical fitness level, and this greater difficulty can lead to reduced motivation for exercise. Based on previous studies,[2,5,6] it can be predicted that the intensity of NW will equal that of LW only when one performs NW at a slower speed than LW. However, no study has compared the effects of NW and LW when the exercise intensity is equivalent in both forms of walking. In addition, no study has been conducted while retaining the same relative intensity of VO_2 between NW and LW. If relative intensity were the same, it appears that the speed, or absolute intensity, should differ. Thus, it is proposed that perceived exertion can be affected because of differences in the muscle groups involved between NW and LW. However, no research has tested this conjecture.

Therefore, the purpose of the present study was to clarify the relationship between perceived exertion levels in NW and LW when the relative intensity is equivalent.

METHODS

Subjects

The subjects were eight healthy male university students who exercise regularly. Their mean±standard error (SE) in age, height, weight, and maximal oxygen uptake (VO_{2max}) are shown in Table 1. All subjects received a complete explanation in advance about the purpose of the experiment, its contents, and safety issues based on the Declaration of Helsinki and the guidelines of the Ethical Committee of Shizuoka University (approval No. 12-26) on studies indicated involving human experimentation; all subjects indicated their informed consent. Concerning NW training, all participants received, before performing the experiment, guidance from an instructor certified by the International Nordic Walking Federation (INWA), who explained the technique of NW and how to walk with the Nordic poles for a minimum of 30 minutes on a treadmill. The participants were asked not to drink alcohol and to get enough sleep before the experiment.

Experimental protocol

Subjects entered the laboratory 30 minutes prior to the starting time of their experimental session. Then, after confirmation of their health condition, their height and body weight were measured.

The Incremental test: Prior to the experiment, subjects performed an incremental test to measure their VO_{2max}, which is an index of exercise intensity. After putting on the electrocardiogram (ECG) (ZS-530P, Nihon Kohden, Tokyo, Japan) electrodes, the subjects put on a ventilation mask and measured their resting metabolism while remaining in a sitting position on the chair for five minutes. They first started to walk at 60 m/min using the method of incremental loading. The speed increased gradually by 20 m/min every two minutes to 200 m/min. The subjects were to perform walking up to and including the speed 120 m/min, and then to begin running when the speed increased to140 m/min. The speed increased gradually by 10 m/min every minute from 200 m/min or until the participant became exhausted.

We developed a regression formula between oxygen uptake (VO_2) and walking speed based on the results of each subject's incremental test. We calculated each subject's speed at 40% of VO_{2max} as the desired exercise intensity for the Nordic

Subject	Age	Height	Weight	VO_{2max}
	(year)	(cm)	(kg)	(ml/kg • min)
A	24	179.6	60.6	63.9
B	21	180.9	79.6	60.6
C	21	168.0	58.2	57.2
D	19	174.7	68.5	56.1
E	19	163.5	65.5	59.5
F	19	174.9	70.7	66.3
G	20	177.0	78.4	61.6
H	20	186.2	72.3	61.9
Mean	20.4	175.6	69.2	60.9
SE	1.7	7.2	7.7	3.3

Table 1: Each subject characteristics.

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walking condition; then, the subjects performed the submaximal exercise test of NW (the NW condition). Thereafter, we substituted the value of VO_2 provided on the NW condition into the regression formula from the incremental test to obtain the speed at which the subject should walk in the level walking test (the LW condition). The subject then performed that test.

The exercise submaximal test for the NW condition and LW condition: For the measurement under each walking condition, subjects put on the ventilation mask and stepped onto the treadmill after putting on the ECG electrodes and their resting metabolism while sitting in a chair was measured for five minutes. Thereafter, subjects performed a warm up in LW at their 40% of VO_{2max} speed for five minutes, and after an interval of three minutes they performed the condition exercise of NW or LW for six minutes. In the case of the NW test, the subjects put on the Nordic poles during the interval. The OMNI scale was administered before starting the six minutes of exercise, at the three-minute point, and immediately after finishing. The measurement of the NW condition and the LW condition for each subject took place on separate days.

All experimental measurements occurred in the laboratory, in temperature of 21.3±0.2 ºC and with humidity levels of 40.9±0.7%. All the experiments were conducted on the treadmill (made by Lode Company for athletice use), and the slope was set at gradient of 5%.

Measurement

The subjects' VO_2 level was measured every 30 seconds during the exercise and resting time. The measurement of the expiration concentration was conducted using a gas analyzer aeromonitor (AE-310S; Minato, Tokyo, Japan), which was tested with a known concentration (O_2: 14.98%, CO_2: 4.62%) prior to the experiment. At the same time, the expiratory volume was estimated by calculating the volume passing through a flow meter (HI-101; Chest, Tokyo, Japan) every 30 seconds, which is based on the Douglasbag method.

Four criteria were used to assess the point of exhaustion: (1) reaching plateau of VO_2, (2) reaching the subject's maximal perceived exertion, (3) a respiration quotient greater than 1.0, and (4) approaching the maximal heart rate (calculated as 220 minus the subject's age). When three of these four criteria were satisfied, we defined the VO_2 at that point as the subject's VO_{2max}.

VO_2 in both conditions was calculated by taking the mean level during the last one minute thirty seconds of steady exercise for the six minutes. VO_2 in both conditions converting it into a percentage of VO_2 to be correlated between a percentage of VO_2 and a heart rate reserve (%HRR).[10] In addition, using a patient monitor (BSM-2401, Nihon Kohden, Tokyo, Japan), we recorded the ECG consecutively and counted an interval every one beat (R splinter-R splinter) for 30 seconds by calculating the value every minute so as to find the heart rate (HR) per minute. HR was calculated as the mean during the two minutes before the end of the measurement and was converted into %HRR.[10]

We measured the perceived exertion using the OMNI scale (eleven levels).[11] We recorded it on the incremental exhaustion tests only with regard to the whole body; for both conditions of the experiment, perceived exertion was recorded for the whole body, upper limbs, and lower limbs.[5] On the incremental test, we recorded perceived exertion immediately before the gradual increase in speed began; in both conditions, we recorded it before the exercise, at the three-minute point, and after the exercise. The statistical analysis refers to the value at the completion of exercise.

Statistics

We calculated the result of the measurements for all subjects in terms of mean±standard error (SE). We used SPSS software version 22.0 for Windows. The effects of all results were determined by one-way analysis of variance (ANOVA) following the Bonferroni method. Significance levels were set at $p<0.05$ or $p<0.01$.

RESULTS

Incremental exhaustion test

The subjects'maximal heart rate (HR_{max}) and VO_{2max} were 198.9±2.6 beats/min and 60.9±1.2 ml/kg/min, respectively. All subjects met at least three of the exhaustion criteria before completing the test.

The exercise submaximal test for the NW and LW condition

The NW condition was conducted at 40% of VO_{2max} speed (94.4±1.8 m/min) as specified by the incremental exhaustion test. As a result, VO_2 was significantly higher than the estimated value provided by the incremental test, by the amount of 11.3±3.7% ($p<0.05$). The percentage of VO_{2max} and the speed attained on the submaximal exercise test were 38.1±3.5% and 94.4±1.8 m/min, respectively, on the NW condition and 41.3±2.4% and 105.1±3.2 m/min on the LW condition, respectively (Figures 1-A and 2). Although there was no significant difference in VO_2, there was a significant difference in speed of 10.7 m/min ($p<0.01$). In addition, no significant difference was found in %HRR, as in VO_2, between the NW condition (44.5±1.5%) and the LW condition (44.0±2.7%) (Figure 1-B).

Figure 3 shows the OMNI scale results at the completion of exercise with regard to the whole body, upper limbs, and lower limbs in that order. Concerning the whole body and the lower limbs, there was no significant difference between the conditions: 2.0±0.4 (whole body), 1.4±0.3 (lower limbs) on the NW condition and 1.3±0.6 (whole body), 2.3±0.8 (lower limbs) on the LW condition. On the other hand, the NW condition

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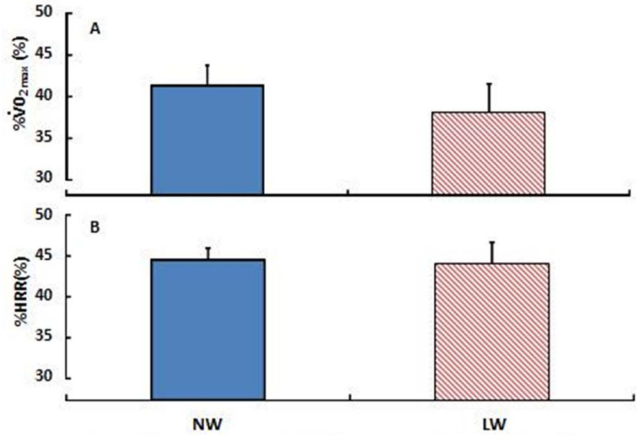

Figure 1: Relative value of exercise intensity for Term NW (■) or (▨). (A) %VO_{2max} (B) %HRR. Error bar denote SE.

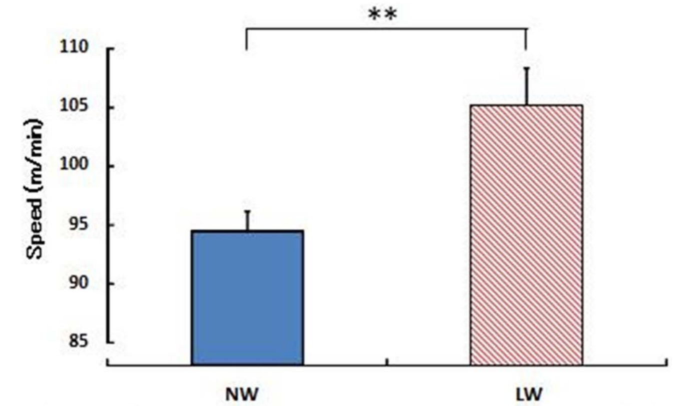

Figure 2: Exercise speed for Term NW (■) or LW (▨). Error bar denote SE.** indicates significant difference between NW and LW (p<0.01).

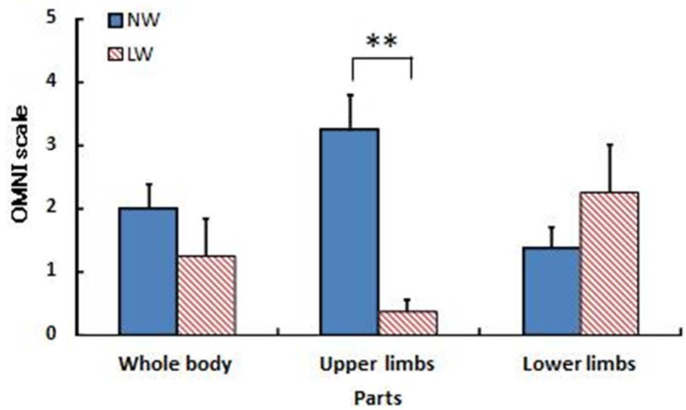

Figure 3: Perceived exertion (OMNI scale) measured immediately after exercise which is Term NW (■) or LW (▨). Whole body, Upper limbs, Lower limbs. Error bar denote SE. **indicates significant difference between NW and LW (p<0.01).

showed a significantly higher value than the LW condition for the upper limbs (NW: 3.3±0.6, LW: 0.4±0.2) (p <0.01).

DISCUSSION

The purpose of the present study was to compare and investigate VO_2, HR, and perceived exertion by implementing exercise tests under the two terms, Nordic walking and level walking, when VO_2 was equalized between two conditions as a measurement of the relative exercise intensity.

In this study, subjects performed at the intensity level of 40% of VO_{2max}, which improves cardiorespiratory fitness[12] and is the walking pattern most commonly used in NW. The growth rate of VO_2 under the NW condition at the speed defined as 40% of VO_{2max} speed increased by 11.3% (p<0.05). When the LW condition was conducted in accordance with this increased VO_2, the speed in the LW condition was, on average, 10.7 m/min greater than that in the NW condition (p<0.01). There was no significant difference between the conditions with regard to %VO_2 and %HRR. Moreover, to perform the LW condition at a perceived exertion level equivalent to the NW condition, the required speed in the LW condition was faster than that required at 40% of VO_{2max}. Therefore, NW exercise intensity is equal to that of LW at an NW speed of about 10 m/min slower.

Based on previous studies, we expected that if exercise intensity was equivalent in both conditions, the LW condition would increase perceived exertion.[3,9] However, the whole-body OMNI scale did not show a difference between the two conditions in the present study. The experimental speed in the present study was equivalent to approximately 90-110 m/min. Thus, integrated electromyogram (iEMG) in the lower limbs of NW was significantly lower in the vastus lateral is and gastrocnemius muscle at this range of speed, as noted by Sugiyama et al[5] In other words, it is likely that the difference might have reduced the burden on the lower limbs on the OMNI scale. It is also said that the burden on the knee joint is reduced in NW.[13] However, no difference was found in the lower limbs on the OMNI scale in this study since subjects' physical fitness levels were high. For subjects in this study, the NW condition was the speed of 40% VO_{2max} and LW condition was that of approximate 51.3% VO_{2max} that was equivalent to fast walking. Thus, it was unlikely to perceive fatigue as for the speed of 40% VO_{2max}-approximate 50%VO_{2max} for six minutes using large muscles of the lower limbs. If untrained or aged subjects performed the NW and LW

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condition in this study, the lower limbs on the OMNI scale of the NW condition would be lower than that of the LW condition. On the other hand, NW is significantly higher than LW in iEMG of the arms at all speeds and a conventional or uphill slope.[5,8,14] As for the upper limbs on the OMNI scale in the present study, the burden on the upper limbs was significantly higher in the NW condition due to the use of Nordic poles. Schiffer et al[4] reported that blood lactic acid concentration in NW becomes higher than that in LW. It would seem that a lactate increase is unlikely to happen at the intensity of 40% of VO_{2max}, but because the OMNI scale score for the upper limbs is high, catecholamine release due to the arm exercise,[15] which represents an early increased expenditure of VO_2, may be large. In this way, it is possible that subjects would generate lactic acid accumulation. In that case, the lactic acid produced in the arms includes the possibility of a lactic acid shuttle that is reused as energy in the lower limb exercise through the blood. As for VO_2, Povop et al[16] reported that an aerobic threshold (AT) was reached earlier in exercise that involves the upper limbs by using poles than in running exercise. Additionally, the activation of the sympathetic nerve because of the mobilization of the muscles in the upper limbs increases the cardiorespiratory function, and this is presumed to increase VO_2. In contrast, because the LW condition at the equivalent speed to the NW condition mainly involves exercise of the lower limbs, the cardiorespiratory action in the LW condition is slower than that in the NW condition since the increase of catecholamine is slower. However, because the amount of change in the central circulatory system is larger during lower-limb exercise, it is thought that the reply using the arms in NW might be equal to the increased burden placed on the lower limbs of LW. This possibility is indicated by the lack of significant difference between NW and LW for the whole body on the OMNI scale.

In future studies, by using subjects who are more accustomed to exercise at intensities of 40% to 60%, we may find greater differences between the two terms. We could confirm more than fourth level of OMNI scale on the upper limbs of the NW condition despite 40% VO_{2max} in this study. Moreover, this is the new knowledge that there is the unique point which NW effects small muscles such as the upper limbs despite the low intensity. If low or moderate intensity of NW increase VO_2 by 11.3%, it may be possible to get exercise whose intensity is near the 40% VO_{2max} from NW which is actually set to 28.7%VO_{2max}. After this, if NW was compared with LW at the same relative intensities based on previous studies[7,17] that LW was improved VO_2 or HR and so on for those who were untrained or aged, it would be clearer evidences of beneficial NW. In other words, NW may be very appropriate regarding a promotion of health. Moreover, we may be able to identify more clearly the physiological characteristics of using Nordic poles by focusing on the sports level or intensities of 70% of VO_{2max} or more.

Eventually, we would like to gain a better understanding of the characteristics of NW by examining subjective perceptions of NW and LW intensity in exercise at various exercise intensities over longer periods of time.

CONCLUSION

Our study has shown that, in NW with equal relative exercise intensity to that of LW performed on a treadmill, VO_2 and HR increased even with slower walking speed. In other words, it is necessary to perform LW exercise at a speed faster than NW in order to attain exercise of equivalent intensity. Only in the arms was perceived exertion during NW reported as higher; there was no significant difference with regard to exertion of the lower limbs or the whole body.

AUTHORS'CONTRIBUTIONS

Significant writing of the manuscript: KT, KS, HO. Concept and design: KT, KS. Data acquisition: KT, KS, EM, YS. Data analysis and interpretation: KT, KS, YS, HO. Statistical expertise: KS. Significant manuscript review and revisions: KS, HO. All authors read and approved the final manuscript.

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CONFLICTS OF INTEREST

There are no conflicts of interest to disclose.

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Physiological Characteristics of Brazilian Jiu Jitsu and Judo as Compared To Muay Thai

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ABSTRACT

The purpose of this study was to determine the physical characteristics, such as strength, flexibility, agility and balance of participants who competed in Muay Thai and how they may differ from those who compete in Brazilian Jiu Jitsu and Judo. Fourteen healthy male participants participated in this study: age's 24.3±3.28 yrs, height 174±3.8 cm and weight 80.51±4.8 kg. Participants were tested on a variety of measures that included three balance tests, one of which was administered with eyes closed; flexibility measurements of flexion, extension, hip internal and external rotation, strength tests included grip strength for dominant and non-dominant hands as well as a timed wall squat test with each leg raised at a time and finally, two agility tests that included the T-test and hexagonal test. There was a significant different between agility and strength measurements between the two martial art combinations of Muay Thai in comparison to Brazilian Jiu Jitsu and Judo. Strength measures indicated that the right grip strength for those competing in Jiu Jitsu/Judo (56.3±11.3) was significantly greater compared to those who competed in Muay Thai (44.5±7.3; p=0.43), while differences for the left hand grip approached significance (p=0.056). Differences in agility were also found with those competing in Muay Thai being significantly faster (4.8±1.39 sec) in the T-test than the Jiu Jitsu/Judo group (7.71±0.54 sec; p=0.001). None of the other measurements were significantly different between the two groups. These findings support the literature where studies have shown that those training for Muay Thai rely more on quickness and speed while those training for Jiu Jitsu/Judo rely more on strength.

KEYWORDS: Martial arts; Strength; Agility; Brazilian Jiu Jitsu; Judo; Muay Thai.

ABBREVIATIONS: BF%: Body fat percentage; Yrs: Years; cm: centimeters; lbs: pounds; kg: kilograms; sec: seconds.

INTRODUCTION

An increase in the popularity of Mixed Martial Arts (MMA) in recent years has raised the interest in issues related to training and fitness necessary for competition.[1] Mixed martial arts include a variety of techniques typical of various combat sports which may include: boxing, wrestling, karate, judo, kickboxing, jiu jitsu. However, there are other martial arts styles that remain popular.[2] While martial arts involve fighting, the rules of how the opponents attack each other differ between the various styles. Our particular interest was whether or not there was also a difference in physical characteristics, such as strength, flexibility, agility and balance in those who competed (recreationally) in Muay Thai and those who competed in Judo and Brazilian Jiu Jitsu.

Muay Thai or Thai boxing was developed in Thailand and is referred to as the art of 8 limbs because it makes use of punches, kicks, elbow and knee strikes, thus using eight "points of contact" as opposed to "two points" (fists) in western boxing and "four points" (hands and feet) used in sport-oriented martial arts. Fighters do wear boxing gloves but can use several parts of their body for offensive and defensive purposes. From a physiological point of view,

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Muay Thai appears to be an intermittent, physically demanding sport, with short phases of maximal or supramaximal intensity spaced by brief recoveries.[3] A Muay Thai match lasts up to 5 rounds of 3 minutes and, as in most martial arts, contestants are weight-matched.[4] Crisafulli et al[3] characterized the energy costs during a Muay Thai boxing match and determined that this was a physically demanding activity with considerable involvement of both aerobic metabolism and anaerobic glycolysis. Thus, training protocols should incorporate exercises that train both aerobic and anaerobic energetic pathways. Turner[4] suggests that Muay Thai athletes, as in other martial arts, gain their fitness through a combination of running, pad work, and sparring, limiting their participation in strength training due to fears of loss of flexibility and gain in body mass.

Judo was created in peacetime for peaceful purposes.[5] It was created in Japan in 1882 by Jigoro Kano as a martial art and combat sport. And, early on, was considered as just one of the styles of Jiu Jitsu. However, the emphasis in Judo is on throwing techniques with the key to throwing based on the ability of the defender to unbalance an opponent.[5] The object then, is to either throw one's opponent to the ground, immobilize or force submission on one's opponent with a grappling maneuver. Other techniques may be used such as forcing an opponent to submit by joint locking or by utilizing a strangling hold or choke.[6] There are currently seven weight categories for both male and female judo competitors.[7] Judo is a dynamic, high-intensity, intermittent sport that requires complex skills and tactical excellence for success. A typical high-level judo match lasts 3 minutes, with 20- to 30-second periods of activity and 5-10 seconds of interruption, while a significant portion of a match lasts 3-4 minutes.[8] To be effective, judo techniques should be applied with accuracy, with strength, velocity and power. The short bursts of energy are supplied by anaerobic metabolism while the ability to sustain the intermittent work, as well as recovery, rely on aerobic metabolism.

Japanese jujitsu usually considers the gentler aspects of fighting and is recommended for smaller or weaker people who would apply leverage to control stronger and bigger opponents. Originally, it was designed for use by an unarmed warrior against an armed opponent.[9] Typical schools continue to focus on the self-defense aspects, such as blocking and throwing an opponent to control him. There is a small focus on striking except to set up grappling techniques. Brazilian Jiu-Jitsu is a descendant of traditional Japanese jujitsu. Jigoro Kano who created judo in the early 20th century removed the striking elements of jujitsu to create an art based on throwing the opponent. Brazilian Jiu-Jitsu was created when one of Kano's students went to Brazil where the emphasis was placed on the ground fighting aspect and the grappling art of Brazilian Jiu-Jitsu was born.[9] Brazilian Jiu-Jitsu is considered a predominantly aerobic sport with moderate activation of the glycolytic system as the bouts last 10 min and, depending on the bracket, there may be multiple fights.[10] Contributing to this is an effort/pause ratio of approximately 10:1 that is a significantly higher proportion when compared to other sports such as judo and wrestling.[11]

While each of these is considered a martial art, they have philosophical differences and involve different techniques and therefore, may differ in their physical demands. Judo and Brazilian Jiu Jitsu[5] appear to rely more on strength, while those who practice Muay Thai reply more on quickness and speed.[4] Thus, the purpose of our study was to determine the strength, flexibility, agility and balance of participants who compete in Muay Thai and how they may differ from those who compete in Brazilian Jiu-Jitsu and Judo.

METHODS

All participants were informed about the procedures of the study and signed informed consent documents. This study was approved by the local Institutional Review Board for the protection of human subjects and permission of the instructors was also obtained before recruiting participants. After obtaining the appropriate permissions, participants were recruited from the training centers and were asked to complete a questionnaire in order to obtain their level of experience, as well as their eligibility to participate in this study. Those that were eligible participated in a series of tests that measured balance, flexibility, strength and agility.

Seven participants were training as Brazilian Jiu Jitsu competitors and seven participants concentrated their training in the art of Muay Thai. Each participant had at least 18 months previous training in his martial art with an average of 24±4.6 yrs of experience for the entire group. Participants were excluded from the study if they had previous major injuries or surgery within 24 months of the study or if they had any minor injuries, such as strains or sprains within 6 months of this study. Participants were also excluded from this study if they were cross training with other martial arts aside from their primary martial art in the category in which they were to be tested in. It was the design of this study to obtain participants from local clubs and training centers that did not participate in mixed martial arts but did train at a competitive level.

Before the tests were administered the fourteen healthy male participants in this study self-reported their ages. Their height and weight were obtained using a Seca 700-13 Physician's Mechanical Beam scale. Body fat percentage (BF%) was determined using three skinfold sites located at the chest, abdomen, and thigh. These measurements were taken with a Lange skinfold calipers.

The following tests were administered in randomized order:

Balance: This test included three trials that were conducted on each leg. With hands on hips and standing on one leg, the other foot was placed with toes against the knee of the support leg. On command, the participant raised up on the toes of the support leg. A stopwatch was used to measure the time until balance was lost or hands were removed from hips. The score was the longest time, in seconds, that the subject was able to maintain balance, on each leg. The second balance test repeated the events of the

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first test, however with eyes closed and the time measured until balance was lost.

Flexibility: The flexibility measurements were taken at knee flexion, knee extension, hip internal rotation and hip external rotation. The range of motion (ROM) was measured in degrees using a 12" Goniometer for 360 degrees. Three measurements were taken at each position, one on each leg, and then averaged.

Knee flexion: The participant was supine on the table with the fulcrum aligned with the lateral epicondyle of the femur, the stationary arm in line with the greater trochanter and midline of the femur and moving arm with the lateral malleolus and midline of the fibula. The ROM was measured when the lower leg was bent back as far as possible. Hip flexion was allowed if that was necessary to improve knee flexion. Normal ROM is 135-150 degrees.

Knee extension: The participant was lying prone with both legs flat on the table with feet beyond the end of the table for full extension. See knee flexion for placement of goniometer. Normal ROM for knee extension is between 0 and -10 degrees.

External rotation: The participant was seated at the edge of the table with knee flexed 90 degrees. The fulcrum was over the anterior aspect of the patella and both arms aligned with the midline of the tibia. While keeping the knee stationary, participant attempted to adduct the foot as far as possible. The ROM was the degrees from the perpendicular stationary arm and the moving arm.

Internal rotation: The participant was seated at the edge of the table with knee flexed 90 degrees. The fulcrum was over the anterior aspect of the patella and both arms aligned with the midline of the tibia. While keeping the knee stationary, the participant attempted to abduct the foot as far as possible. The ROM was the degrees from the perpendicular stationary arm and the moving arm.

Strength: Handgrip strength was measured using a Baseline Hydraulic Hand Dynamometer from Fabrication Enterprises. Participants completed three trials with each hand. The elbow was maintained at a 90 degree angle, keeping the arm close to the body. The highest value was used for analysis.

A second strength test was administered to determine leg strength. A wall squat test was used in which the participants had their back against the wall, forming a 90 degree angle between the wall and thigh. They were asked to lift one leg off the ground and were timed to measure how long the correct position could be maintained. One trial on each leg was completed.

Agility: Two agility tests (T-test, hexagonal timed test) were administered. For the T-test, three cones were set five meters apart in a straight line. A fourth cone was placed 10 meters from the middle cone to form a "T." Participants started at the cone at the base of the "T" and ran to the middle cone, touches the cone then side steps five meters to the left cone, touches, side steps 10 meters to the far cone, touches, side steps five meters to the middle cone, touches, then runs 10 meters backwards to the base of the "T" and touches cone. Time is from start at base of the "T" to touching cone at base of "T."

The Hexagonal Obstacle Test consists of a six-sided hexagon with 66 cm sides. The participant begins by standing in the middle of the hexagon. At the command to "go" the participant jumps over the line, outside the hexagon and then back in, then over the next side, back in, out and in, until he has completed three circuits. The time for the three circuits was recorded. Three minutes rest is followed by a repeat of the test. Significance was determined by setting the alpha level at $p \leq 0.05$. Data was later averaged and analyzed using a paired, two tailed T-test in SPSS 19.0. Data was displayed using graphs and tables organized in Microsoft Excel 2010.

RESULTS

The average age of the participants was 24±4.6 yrs and consisted of seven subjects involved in Brazilian Jiu Jitsu and Judo training and seven participants who were practicing Muay Thai. Height was 174±9.99 cm and weight was 80.42±19.25 kg with a body fat percentage of 9.1±3.4 % (See Table 1).

	Mean	SD	Maximum	Minimum
Age (yrs)	24	4.6	28	19
Height (cm)	174	9.9	188	150
Weight (kg)	80.4	19.3	97	67
Body fat (%)	9.1	3.4	5.36	10.42

Table 1: Demographics of participants.

No significant difference was found for balance measurements on the left balance test for Jiu Jitsu/Judo (14.6±6.6 sec) or for Muay Thai (18.1±8.83 sec; p=0.39) or right balance test for Jiu Jitsu/Judo (20.95±6.5 sec) or for Muay Thai (17.7±11.1 sec; p=0.51). The blind balance test also found no significant differences with averages of 6.25±2.8 sec for Jiu Jitsu/Judo and 5.9±4.1 sec for Muay Thai (p=.88). These results are shown in Figure 1.

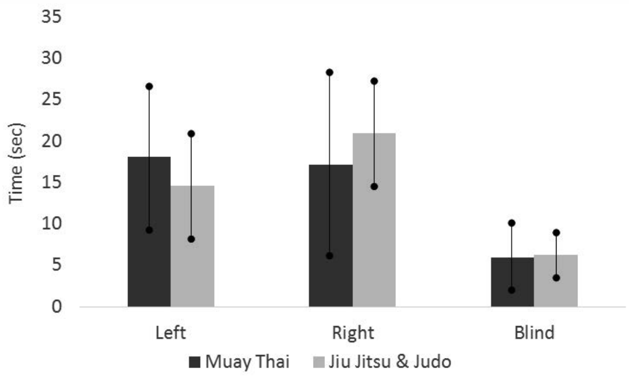

Figure 1: Balance tests on right and left legs and with eyes closed reported as time in seconds.

Figure 2 shows the results for the measures of flexibility. Flexion was 145.1±4.1 degrees (Jiu Jitsu/Judo) and 144±10.9

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degrees (Muay Thai) resulting in a difference that was not significant (p=0.25). The measures for extension for Jiu Jitsu/Judo (-2.2±3.9) and Muay Thai (-3.64±2.13 degrees) were also not significantly different (p=0.27). Internal hip rotation was 51.12±9.29 degrees (Jiu Jitsu/Judo and 54.28±11.04 degrees (Muay Thai) was also not significantly different (p=0.31). Finally, external hip rotation was 39±10.5 degrees for Jiu Jitsu/Judo and 39.42±8.37 degrees for Muay Thai with a difference that was not significant (p=0.53).

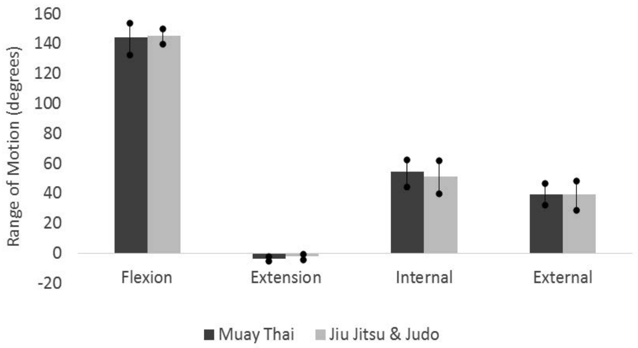

Figure 2: Range of motion in degrees for flexion, extension, internal and external rotation that are the average of both legs.

The results for the strength tests indicated a significant difference (p=0.043) between the two groups for right hand grip strength. Jiu Jitsu/Judo participants were stronger (56.3±11.3 lbs) than the Muay Thai participants (44.5±7.2 lbs). While the results for the left hand grip strength of the Jiu Jitsu/Judo participants (54.8±8.1 lbs) were not significantly different from those who participated in Muay Thai (49.6±8.9 lbs), it did approach significance (p=0.056). All participants claimed to be right-hand dominant and these results are found in Figure 3.

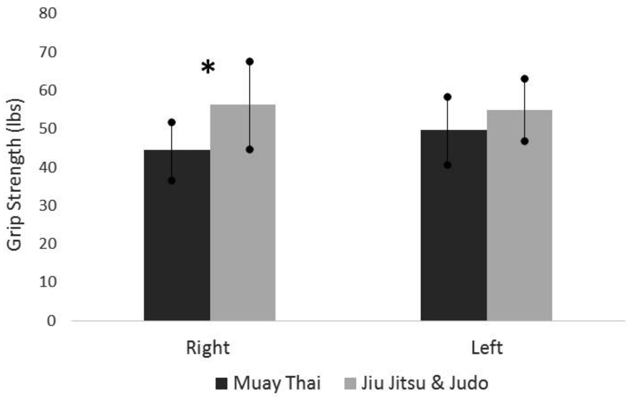

Figure 3: Right and left grip strength measured in lbs (* indicates statistically significant difference in right hand grip strength between the two groups, p<0.05).

Leg strength was measured using a one-legged wall sit. Neither the right wall squat (Jiu Jitsu/Judo 47.4±11.3 sec; Muay Thai 44.5±7.3 sec) nor the left wall squat (Jiu Jitsu/Judo 53.2±27.7 sec; Muay Thai 45.4±20.7 sec) were significantly different (p=0.85 and p=0.30, respectively. These results are seen in Figure 4.

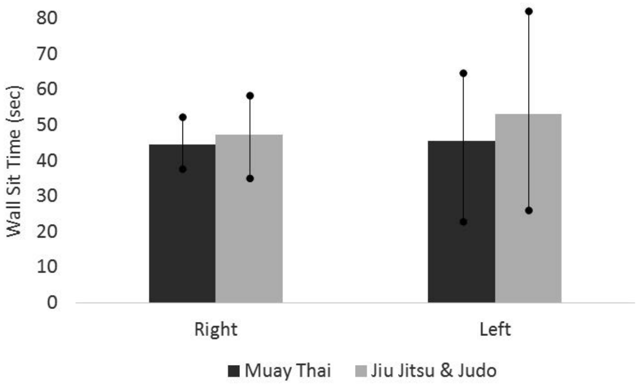

Figure 4: Right and left leg wall squat reported as time in seconds

The significant difference (p=0.001) found in the T-test for agility indicated that those practicing Muay Thai (4.8±0.54 sec) were faster than those practicing Jiu Jitsu/Judo (7.71±1.38 sec). However, no significant difference (p=0.90) was found between Jiu Jitsu/Judo (15.68±1.1 sec) and Muay Thai (13.84±1.2 sec) for the hexagonal obstacle test and these results are noted in Figure 5.

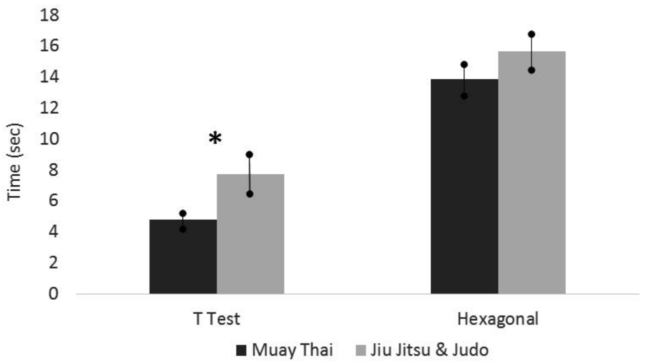

Figure 5: T-test and hexagonal agility tests (* indicates statistically significant difference in T-test, p<0.05).

DISCUSSION

It was hypothesized that there would be significant differences between the two categories of martial arts based on the requirements of their respective training and competition. Although there were not significant differences in all categories between these two fighting styles, there were some significant differences found in the areas that distinguish their styles, namely, strength and agility. The significant differences between the two martial arts demonstrated that the agility of the Muay Thai participants, at least in the T-test, was significantly faster than that of the Jiu Jitsu/Judo participants (p=0.001, Figure 5). However, no significant differences were found in performance of the hexagonal agility test and can also be seen in Figure 5. This was probably due to the steep learning curve required to perform this test and one practice repetition may not have provided adequate time to learn this testing sequence. Further studies may want to give participants more detailed instructions

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and allow participants more time to practice prior to the recorded testing.

The Brazilian Jiu Jitsu/Judo group were determined to be significantly stronger for the right hand grip measurement (*p*=0.043) but not for the left hand grip measurement. However, this measurement approached significance (*p*=0.056). It was also observed that while 85.7% of Muay Thai subjects claimed to have right hand dominance, all Muay Thai participants demonstrated left hand dominance during the Grip Strength tests (Figure 3). This may be due to the practice of cross jabs in Muay Thai and the common practice of holding a stance that allows the competitor to face their opponent in a square setting, minimizing their opponent's ability for open throws and kicks. This may be a contributor as to why right hand dominance was found to be significant but left hand dominance was not. Further research is needed to investigate this observation.

While Muay Thai has a heavy focus on body conditioning[3] and has been specifically designed level of fitness promoting endurance needed for ring competition, Brazilian Jiu Jitsu appears to concentrates more on muscular strength increases as well as increase of muscle fiber recruitment rate over time with training due to its similarities with resistance training.[10]

Further research may want to extend the testing to include measurements of aerobic and anaerobic components. While the types of martial arts evaluated here appear to involve both the anaerobic and aerobic pathways, there do appear to be some differences. Brazilian Jiu Jitsu and Judo appear to have more of an aerobic component[10,11] while those competing in Muay Thai rely more on anaerobic pathways.[3] Recommendations for further research would also be to extend this study to the female population as well as the older population in order to determine the effects of these martial arts over a more extended period of time. The results of further research may provide training guidelines for Ultimate Fighting Championships and Mixed Martial Arts competitors.

CONCLUSION

Much attention has been given to mixed martial arts over the past 25 years and is a sport that incorporates the use of both striking and grappling, both standing and on the ground. Those competing in MMA draw from a variety of other combat sports and martial arts. The various martial arts have some overlap, however, taken individually, each martial art has unique physical demands requiring training focused on the techniques and expectations inherent within it. This was seen in our study in the significant differences in strength for those participating in Brazilian Jiu Jitsu/Judo *versus* those with greater speed and agility who participated in Muay Thai. The addition of females as participants as well as aerobic and anaerobic testing will greatly expand the knowledge of the physical demands of these sports.

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AUTHORS CONTRIBUTIONS

Both authors have contributed to the data collection and writing of this manuscript.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

CONSENT STATEMENT

Participants' Consent Statement was approved by the Institutional Review Board for the Protection of Human Subjects.

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Opinion

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Will the 'Pokémon' be Heroes in the Battle Against Physical Inactivity?

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Physical inactivity increases the risks of dying prematurely, dying of heart disease, and developing diabetes, colon cancer and high blood pressure.[1] However, there exists a large portion of the population who remain physically inactive and others who are active but do not engage in a sufficient amount of physical activity to maintain health.[2] Multiple factors underlie this dilemma, including personal, social and environmental issues, all of which have made the promotion of physical activity a challenging endeavor. Interestingly, in the past few months (as of early July, 2016) anecdotal evidence suggests more people have been going outside and engaging in physical activity. This is not related to any "national fitness initiatives" or the like, but simply as part of playing a game called 'Pokémon Go'. This new mobile gamming application uses an augmented reality and GPS location systems to create a map of the local environment. Individuals can use their phones to track and catch Pokémon (virtual creatures). The most intriguing aspect from a public health perspective is that people must actually engage in physical activity (e.g. walking, biking) to be successful playing the game. Amit Khera, MD, Director of Preventive Cardiology, UT Southwestern Medical Center, Dallas, Texas notes, *"Unlike many apps or video games which are largely sedentary endeavors, this one promotes physical activity in the outdoors. Importantly, the physical activity is a by-product rather than an explicit component, such as one sees with other "Fit" video games that can turn off some young adults. So, kids and adults are getting outdoors, engaging in social interaction, and are participating (unintentionally) in physical activity - it is a win-win all around"!* With reported downloads of the game exceeding 100 million since July 2016, why is this particular game, with inherent design features to promote physical activity, so popular? Maybe even more importantly, can this popularity (as well as the associated increased physical activity participation) be sustained over a long enough period to impact public health?

As noted by Dr. Khera, the physical activity component is actually a by-product of playing the game, but activity has been cleverly been engineered into the game as a major determinant of game achievement and success. In addition to having a required physical activity component, there are other design features to help sustain player interest. Several articles have previously discussed the potentially "addictive" features of online gaming and the unique design features of the Pokémon game which can influence player behavior.[3] These factors include the random rewards structure,[4] the Pokémon nostalgia,[5] the concept of collecting items,[6] and incorporation of an augmented reality. Additionally, the game itself is free to play on mobile devices, is easy to play, incorporates the potential for social interaction, provides feedback and recognition for achievement and really has no definitive end point.[3] It would appear that in combination, these psychosocial factors may provide the stimulus needed to engage more individuals in physical activity. While the potential health benefits exist, risks associated with the game have also been identified including; increased risk of injury, abduction, trespassing, violence, and cost (of in game purchases).[7] However, these risks can largely be reduced with appropriate precautions, attention and parental oversight in the case of minors. All factors being considered, the potential health benefits of increased physical activity as related to the Pokémon Go game would seem to outweigh the preventable risks, with one key issue in question. Do (or will) Pokémon Go players experience any significant physical activity related health benefits?

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Intuitively, one might argue the inevitable health benefits of playing Pokémon Go as originally designed to promote walking or biking outdoors (e.g. not driving or riding around in a slow moving vehicle) and support the "it's better than nothing" argument. However, one must also consider that attainment health benefits for healthy adults aged 18-65 have been related to meeting the recommended minimum physical activity guidelines involving 30 minutes of moderate intensity exercise (i.e. brisk walking) on 5 days each week.[2] The Physical Activity Guidelines for Americans, issued by the U.S. Department of Health and Human Services, recommend that children and adolescents aged 6-17 years should have 60 minutes (1 hour) or more of moderate physical activity each day. Are players meeting these guidelines? While playing the game, players are tracked *via* their phone's GPS to determine specific location. Both speed and distance covered are also monitored and then used as variables in the reward delivery system. For example, in order to "hatch Pokémon eggs" and collect new Pokémon, as well as points towards advancement in player level, one must walk or bike various distances (i.e. 2, 5 or 10 kilometers). This process requires the collection and storage of user mobility data. Per the user agreement, Niantic as the game developer has the right to share non-identifying information with third parties "for research and analysis, demographic profiling and other similar purposes". Thus, if a clever investigator were able to gain access to user mobility data, coupled with the user demographic data, they could begin to more clearly answer important health questions involving physical activity. For example, are players are meeting age appropriate physical activity recommendations while playing the game? Consider the possibilities if Niantic was encouraged to incorporate a few activity-related surveys as part of the game, just a few simply questions could provide a wealth of health information on a global scale. For example, are the individuals currently playing Pokémon Go previously involved in physical activity or did the game actually engage previously inactive persons. Data could also be collected which could be used to determine the most effective game design features to promote positive health behaviors to help sustain or even increase physical activity; as part of the Pokémon Go game or even in the development of future games.

So, back to our original question, will the Pokémon be heroes in the battle against physical inactivity? Anecdotal evidence suggests there are many individuals playing the game and logging many kilometers catching the elusive Pokémon. This initial surge in physical activity participation represents movement in a good direction, but only time will tell regarding the sustainability and the potential impact on health. If the game was designed, at least in part, to help increase physical activity as suggested by its creators, Niantic could certainly do more to help assess the effectiveness. Let's hope for the best, but we may need to wait for results from the next U.S. Department of Health and Human Services report on physical activity and the prevalence of inactivity related diseases to determine if the Pokémon are deserving of hero status.

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