European Journal of Human Movement

OPEN ACCESS

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The effects of 24 weeks of muay thai and bodybuilding training programs on lower limb performance, balance, and coordination: Comparison of athletic performance Between the Muay Thai and Bodybuilders

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Received: 31/01/2021; Accepted: 15/11/2021; Published: 31/12/2021

Abstract: The aim of this study was to compare balance, coordination, and lower limb performance values between Muay Thai (MT) and bodybuilders (BB) training groups. A total of 35 (17 MT group and 18 BB group) participants were included in the study. MT and BB training programs were performed three sessions per week for 24 weeks. Lower limb performance, coordination static and dynamic balance were determined. There was no significant difference between the groups in any components of dynamic balance (p= .336-.989). The groups were similar for both their dominant and non-dominant lower extremities in terms of static balance (p=.319-.483).The participants in the MT group completed the Hexagon Test in a shorter time compared to the BB group, while the effect size was large (d=0.907; p=.011). While the jump distance on the dominant leg was similar in both groups (p= .66), the jump distance on the nondominant leg was longer in the MT group and the effect size was large (d=0.738; p =.038). The study concludes that compared to the BB group, MT group had higher levels of coordination and nondominant lower extremity functional performance. Yet, there was no difference between the groups in terms of static and dynamic balance and dominant leg performance.

Keywords: Muay thai, body building, balance, coordination, lower limb performance

1. Introduction

It is stated that martial arts can also lead to improvements in coordination, balance, and muscle strength required for physical fitness (Bu et al., 2010; Fong & Ng, 2011; Tota et al., 2014). Studies have shown the desirable effects of Far Eastern martial arts on healthy individuals and individuals with various diseases, and it is reported that these sports can enhance physical and motor abilities (Bu et al., 2010; Burke, Al-Adawi, Lee, & Audette, 2007). Muay Thai (MT) is a branch of sports that contributes to the physical and spiritual development of the athletes, increases personal skills and self-confidence, and teaches discipline and regularity (Turner, 2009). Van Der Veere stated that MT is a coordination sport which involves concerted cooperation of the muscular and neural systems (Van Der Veere, 2012). MT athletes perform various combinations of upper and lower limb movements, requiring advanced balance and coordination skills (Jungman & Wilson, 2016). Some of the MT techniques, in which the athlete is in no contact with the ground, require higher balance and

coordination skills (Crisafulli et al., 2009; Turner, 2009). However, there is a limited number of studies in the literature investigating the relationship between MT and balance (Abidin, Ooi, & Chen, 2018; Jungman & Wilson, 2016; Turner, 2009).

Bodybuilding (BB) is one of the most fundamental exercise methods to increase coordination, balance and muscle strength required for physical fitness (Steele, Pope Jr, & Kanayama, 2019). Studies indicate that resistance exercises, which are the basis of BB, not only increase muscle strength, but also influence neural pathways and increase coordination (Lesinski, Prieske, & Granacher, 2016; Mitchell, Slater, Hackett, Johnson, & O'connor, 2018). It is also reported that multiple joint exercises included in BB programs improve coordination, balance, and proprioception (Vaughn & Micheli, 2008).

Differences in the application of sports branches cause athletes to have different levels of physical and physiological features. Although MT and BB are completely different disciplines, it has been shown in studies that both of them contribute to the physical development of their athletes (Bu et al., 2010; Burke et al., 2007; Kim, 2018). Studies comparing various sports branches have reported that both MT and BB contribute to the development of the athletes and trainers. These studies have an important place in highlighting the effectiveness of these methods in improving balance, coordination, and other physical parameters. Therefore, the present study aimed to compare balance, coordination and lower extremity functional performance values between MT and BB training groups. As the hypothesis of the study, it was predicted that there is a difference in balance, coordination, and functional parameters between the two groups.

2. Materials and Methods

Subjects — Nine different clubs and sport centers were screened and 18- to 35-year-old individuals regularly engaged in MT or BB were invited to join the study. All the volunteers participating in the study signed the informed consent form and filled personal data forms. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by University Ethics Committee of Non-Pharmaceuticals and Non-Medical Device Research (2020/243). Additionally, National Clinical Trials (NCT) number (NCT04563312) was obtained from the ClinicalTrials.gov Protocol Registration and Results System website. The number of individuals in the study based on the single leg hop test; For effect size (Cohen's d) = 0.7, alpha = 0.05, and 80% statistical study power, the sample size required to include at least 18 individuals for each group in this study is G-power (G * Power, Ver. 3.0.10, Universität Kiel , Germany) program (Faul, Erdfelder, Lang, & Buchner, 2007). Thus, a total of 35 participants, 17 individuals (14 men and 3 women) engaged in MT and 18 individuals (13 men and 5 women) engaged in BB were included in the study. Dominant leg was defined as the preferred leg for kicking a ball, since previous studies have reported this definition as the most accurate in determining interlimb differences in unipedal postural control (Arunee Promsri, Haid, & Federolf, 2018; A Promsri, Haid, Werner, & Federolf, 2018). Participants who (a) trained less than 3 sessions per week; (b) had lower limb injury for more than 1 month; (c) had a history of surgery, or chronic and progressive disease in their lower limb; and (d) had scoliosis or any other orthopaedic or neurological problems were excluded from the study.

All evaluations were conducted at the same time of the day for each participant and under similar environmental conditions (~21 ◦C and ~60% humidity). All volunteers were advised to maintain their normal level of physical activities between testing sessions. Before taking the tests, 3–5 min stretching exercises were applied to the participants following a five-minute warm-up period in bicycle ergometer in a slow tempo. To minimise bias, the order of limb dominance (dominant, non-dominant side) and tests were randomized.

Methodology—

Muay Thai training program — The supervised MT training program was performed for 24 weeks. A physical education professional with substantial experience in MT supervised all participants during the intervention, in order to ensure consistent and safe performance. Each MT training session consisted of 15 min of warm-up, composed by stretching exercises for the major upper- and lower-body muscle groups and motor coordination exercises, such as jumping jacks, skipping and jumps. Following the warm-up, 3 sets of 60 kicks, 30 kicks for each leg, with 30 s of rest between sets were performed, followed by 3 rounds of combined punches, kneeing, elbowing with 30 s of rest between rounds, and 3 rounds of sparring with 1 min, performed in this exact order. Finally, 15 min of the session were used for cooling down. Session length was 1 hour. It was performed three sessions a week (Mondays, Wednesdays, and Fridays). During the study period the participants were admonished not to perform any other type of physical exercise program (Rapkiewicz et al., 2018).

Bodybuilding training program — BB group trained each muscle group agonistically three times per week, by training the whole body on three different days for 24 weeks. All workouts were separated by 48 hours. The number of sets performed per week consisted of nine total sets, per muscle group (Thomas & Burns, 2016) (see Tablo.1).

Table.1. Bodybuilding training routine

Muscle Group	Monday	Wednesday	Friday
Pectoralis	Flat Presses	Flat Presses	Incline Presses
Upper Back	Pulldowns	Pulldowns	Rows
Quadriceps	Leg Press	Lunges/Squats	Hack Squats
Pectoralis	Flat Presses	Flat Presses	Incline Presses
Upper Back	Pulldowns	Pulldowns	Rows
Gastrocnemius	Standing Calf Raises	Standing Calf Raises	Standing Calf Raises
Deltoids	Shoulder Press	Lateral Raises	Lateral Raises
Biceps	Seated Dbell Curls	Seated Dbell Curls	1 Arm Bench Curls
Triceps	Triceps Pushdown	Triceps Pushdown	1 Arm Triceps Ext.
Hamstrings	Seated Leg Curl	Seated Leg Curl	Back Extension
Sets × Reps	3×8–12 all ex.	3×8–12 all	ex. 3×8–12 all ex.

Workouts were performed with 48 hours rest between each workout, three days per week. Dbell=dumbbell, Ext=extension

Data Collection —

Balance assessment —

Y balance test — Y balance test (YBT) is a simplified version of the Star Excursion Balance Test to measure dynamic balance. It requires the athlete to balance on one leg while reaching as far as possible with the other leg in three directions: anterior, posteromedial, and posterolateral (Shaffer et al., 2013). ICC for intrarater reliability of the test ranges from 0.85 to 0.91 and for interrater reliability ranges from 0.99 to 1.00 (Plisky et al., 2009). In order to eliminate any differences that might be caused by the shoes, the participants were asked to remove their footwear. The participants stood on the center platform of the YBT kit. While maintaining a single leg stance, they were

asked to reach in each of the three directions - anterior, posteromedial, and posterolateral- with their free leg and then return to the starting position. They performed 3 trials for each direction with both their dominant and non-dominant legs. For each direction, the average of 3 trials was calculated and recorded in centimeters. (Shaffer et al., 2013).

Flamingo balance test — Flamingo balance test (FBT) measures whole body balance. Tsigilis et al. (Tsigilis, Douda, & Tokmakidis, 2002) stated the ICC of the test as 0.71 The participants were asked to stand on a 4-cm-wide wooden beam with their shoes removed. While balancing on one leg, they flexed their free leg at the knee and held the foot close to the buttocks. The evaluator started the stopwatch as the athlete got hold of his/her balance in this position and stopped the stopwatch each time the person lost balance (either by falling off the beam or letting go of the foot being held). The number of falls in 60 seconds of balancing was counted for each participant (Kranti Panta, 2015). Although only the dominant leg is tested in most of the previous studies, we believe that the bilateral measurements in this study will contribute to the literature.

Coordination assessment — Hexagonal test (HT) measures coordination, agility, and balance. Beekhuizen et al. (Beekhuizen, Davis, Kolber, & Cheng, 2009) reported the ICC value of the test as 0.93. Using athletic tape, a hexagon was marked on the floor (the length of each side= 66 cm). The participant was asked to remove the footwear and start with both feet together in the middle of the hexagon facing the front line. On the command 'go', they jumped ahead across the line, then back over the same line into the middle of the hexagon. They were asked to continue this pattern for three full revolutions. For each participant, the time taken to complete three full revolutions was recorded as the test result (Beekhuizen et al., 2009).

Lower extremity functional performance assessment — Single leg hop test (SLHT) measures lower extremity functional performance. The ICC value of the test is reported as 0.85 (Sawle, Freeman, & Marsden, 2017). In order to eliminate any possible differences due to the shoes, the participants were asked to remove their footwear. The tests were carried out on a tatami mat to ensure a safe and comfortable landing for the participants. For each participant, the distance from the start line to the heel of the landing leg was measured and recorded in centimeters. Care was taken to ensure the balance of the participant at the starting point. The test was repeated three times and the average was calculated (Sawle et al., 2017). The test was applied bilaterally aiming to contribute to the literature.

Statistical Analysis — SPSS version 22 (IBM SPSS Statistics 22.0, IBM SPSS® software, Chicago, IL) software was used for data analysis. The "Shapiro-Wilk Test" was used to examine whether the variables had normal distribution. Comparison of numerical data between the groups was analyzed using "Independent Sample T-test" for normally distributed data, and "Mann Whitney U Test" for non-normally distributed ones. The level of significance was set at $p<0.05$. The effect size was displayed with Cohen's d, with 0.2, 0.5, and 0.8 values of d for small, medium, and large effects, respectively (Cohen, 2013).

3. Results

Characteristics data of the participants are presented in Table 2. The age and body weight of the BB group were found to be higher than MT group ($p<.001$; $p=.005$, respectively) (Table. 2).

There was no significant difference between the groups in any components of the YBT ($p=.336$-$.989$) (Table. 3).

The groups were similar for both their dominant and non-dominant lower extremities in the FBT ($p=.319$-$.483$) (Table. 3).

The participants in the MT group completed the Hexagon Test in a shorter time compared to the BB group, while the effect size was large (Cohen's $d > 0.5$) ($d=0.907$; $p=.011$) (Table. 3).

Regarding the SLHT results, while the jump distance on the dominant leg was similar in both groups ($p= .66$), the jump distance on the nondominant leg was longer

in the MT group and the effect size was large (Cohen's d > 0.5) (d=0.738; p =.038) (Table. 3).

Table. 2. Characteristics data of the participants

Characteristics data	MT (n=17)				BB (n=18)				
	min	max	mean	SD	min	max	mean	SD	p†
Age (years)	18.00	26.00	20.65	2.34	19.00	35.00	25.89	4.83	<0.001*
Height (cm)	150.00	182.00	172.06	9.67	153.00	185.00	172.61	8.13	0.961
Weight (kg)	46.00	75.00	61.06	9.19	47.00	95.00	73.61	14.33	0.005*
BMI (kg/m2)	20.44	22.64	21.54	1.45	20.07	27.75	23.91	2.23	0.052
Sports experience (years)	3.00	5.00	4.00	0.02	2.70	5.00	3.85	0.03	0.956

† Mann Whitney U test, * p<0.05, MT: Muay Thai; BB: Bodybuilders, BMI: Body mass index, min: minimum, max: maximum, SD: Standard deviation

Table. 3. Lower Limb Performance, Balance and Coordination Differences Between the Muay Thai and Bodybuilding training groups

Variables		MT (n=17)				BB (n=18)					
		min	max	mean	SD	min	max	mean	SD	p†	d
YBT (cm)	**ANT_D**	66.66	92.00	82.74	5.97	68.66	99.00	82.77	7.61	0.989	n.s.
	ANT_ND	71.00	91.33	84.11	5.68	68.66	96.33	82.16	7.75	0.400	n.s.
	PL_D	84.66	106.00	92.60	5.68	80.00	104.33	91.55	7.96	0.655	n.s.
	PL_ND	80.00	106.33	95.19	6.30	79.00	103.00	92.55	6.86	0.244	n.s.
	PM_D	76.33	97.33	87.66	6.34	70.33	102.33	84.70	9.60	0.288	n.s.
	PM_ND	74.33	104.00	88.08	7.39	70.33	101.00	85.26	9.61	0.336	n.s.
HT (sec)		11.40	19.72	14.81	2.41	12.60	25.90	17.60	3.62	0.011*	0.907^
FBT (sec)	**D**	3.00	21.00	9.18	5.21	0.00	27.00	11.33	7.18	0.319	n.s.
	ND	2.00	16.00	8.82	4.33	1.00	31.00	11.44	7.68	0.483	n.s.
SLHT (cm)	**D**	143.00	230.66	189.06	23.79	113.00	211.00	173.22	25.52	0.066	n.s.
	ND	137.00	242.66	189.62	28.32	135.33	207.00	170.98	21.97	0.038*	0.738^

† Mann Whitney U test, * p<0.05, MT: Muay Thai; BB: Bodybuilders; YBT: Y Balance Test; HT: Hexagonal Test; FBT: Flamingo balance test; SLHT: Single Leg Hop Test; ANT: Anterior direction; PL: Posterolateral direction; PM: Posteromedial direction; D: Dominant side; ND: Non-dominant side; min: minimum, max: maximum, SD: Standard deviation, cm: centimeters, sec: second, n.s.: no statistically significant differences, ^large effect size (Cohen's d > 0.50).

4. Discussion

This study was conducted to compare static and dynamic balance, coordination, and lower extremity functional performance between MT and BB training groups. According to the results, there was no difference between the groups in terms of dominant and nondominant balance parameters and dominant lower extremity functional performance. However, MT group

had higher scores in nondominant lower extremity functional performance and coordination parameters.

MT requires high levels of physical and physiological conditioning. MT athletes fight their rivals with kicks and punches using their knees and elbows (Abidin et al., 2018; Turner, 2009). These athletes are trained according to the tactics and techniques required for their matches. In addition to tactical and technical work, these trainings include exercises such as squat, pull-ups, push-ups, and shuttle exercises to increase strength, and fitness exercises such as running and skipping rope to improve endurance (Turner, 2009). The purpose of the comparison of the two groups in this study was to determine the differences between strength, balance, and coordination trainings in a functional sports program (i.e., MT) and the trainings with standard body building equipment (i.e., BB).

Studies comparing different sports branches make significant contributions to the athletes and trainers that practice these sports. Due to the differences in the practices and trainings of various sports branches, they may have different physical and physiological requirements. MT and BB have different training systems; thus, their physical and physiological needs are also different. To the best of our knowledge, there is no study in the literature comparing these two sports. Although studies on BB have had great improvement in recent years (Kim, 2018; Lesinski et al., 2016), the number of studies on MT is quite limited (Mohamad et al., 2017). In this context, the present study aims to contribute to the literature.

In our study, the age and body weight of BB group were found to be significantly higher than MT group. This difference in body mass can be explained in 2 ways, as stated in previous studies (Barley, Chapman, & Abbiss, 2017; Pietraszewska, Burdukiewicz, Stachoń, & Andrzejewska, 2013; Turner, 2009): (1) BB focuses on body building and increasing muscle mass, thus leads to an increase in the athletes' body weight; (2) Lower body mass helps MT athletes with better attack techniques; this is particularly important as their competitions are held according to different body weight categories.

Athletes improve their balance and postural control skills by continuously working out in vigorous training programs and matches (Paillard, 2019). Classified as static and dynamic, balance is an important parameter in reducing the risk of injuries and increasing performance in athletes (Paillard, 2019; Ricotti, 2012). Para and Mruk (Para & Mruk, 2017) and Woodward (Woodward, 2009) stated that combat sports, including MT, can improve balance and that the practical use of MT for balance training is increasing. Similarly, BB is also reported to improve balance through resistant exercise trainings, especially using free weights (Granacher, Gollhofer, Hortobágyi, Kressig, & Muehlbauer, 2013; Weiss et al., 2010). According to the FBT and YBT results of the present study, there was no significant difference between the MT and BB groups in terms of static and dynamic balance. This suggests that the striking techniques performed by MT athletes while maintaining single leg stance seem to have minor/nonsignificant impact in improving their static and dynamic balance. In order to determine which of the two groups had higher balance improvement, future studies are recommended to include a sedentary group as the third group or to investigate the improvement after a certain period of balance training.

According to our results, MT group had higher coordination levels compared to the BB group. This is because MT need advanced coordination skills for their striking techniques to score higher in their matches (Vasilica, Predoiu, & Mitrache, 2011). Furthermore, movements that require advanced coordination are included in MT training programs and practices (Jungman & Wilson, 2016; Turner, 2009) . On the other hand, the lack of speed, endurance, and flexibility movements in BB training programs may create a disadvantage for this group compared to MT athletes.

Our study results indicate that MT and BB groups were similar in terms of dominant

lower extremity functional performance. However, a significant difference in favour of the MT group was observed in nondominant lower extremity performance. The absence of difference between dominant and nondominant leg performance in the BB group was an expected result due to their symmetrical training approaches. MT athletes, however, perform movements and strike combinations with their dominant extremities while maintaining stabilization and support on their nondominant legs (Jungman & Wilson, 2016; Turner, 2009). In other words, to enhance coordination and stabilization on their supporting legs, MT athletes create a strong ground contact force necessary for successfully performing efficient strikes. Unlike MT athletes, BB athletes usually get double support on both legs to work out with weights and equipment (Mitchell et al., 2018). This might be the potential reason for the difference in nondominant lower extremity functional performance between the two groups.

This study has some limitations that need to be addressed. The first is that due to the absence of a sedentary control group, the results cannot be compared to healthy sedentary individuals. The second limitation is that other performance parameters (such as agility, quickness, explosive strength) are not evaluated in the study. Finally, there was no pre-intervention measurements.

5. Practical Applications

The study concludes that compared to the BB group, MT group had higher levels of coordination and nondominant lower extremity functional performance. Yet, there was no difference between the groups in terms of static and dynamic balance and dominant leg performance. Therefore, we recommend that coordination and functional trainings should be included in the training programs of BB athletes to prevent injuries. Balance plays a key role in preventing injuries in sports that include functional and sport-specific movements such as MT. Yet, the balance scores of MT group seem to be similar to those of BB group who mainly practice with exercise equipment, without focusing on functional exercises. Thus, we recommend adding static and dynamic balance trainings to MT training regimens.

Funding: This research received no external funding.

Acknowledgments: Non declare

Conflicts of Interest: The authors declare no conflict of interest.

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