© *Yoshin Academy*
"Ido Movement for Culture Journal of Martial Arts Anthropology",
Vol. 24, no. 1 (2024), pp. 1–7
DOI: 10.14589/ido.24.1.1

BIOMECHANICS & COACHING

Mandra Janep[1(ABCDEFG)], Noorzaliza Osman[2(ACDEF)],
Nur Ikhwan Mohamad[3(ACDEF)], Kevin Tan[4(ABCDE)], Zulezwan Ab Malik[5(ACDEF)],
Ali Md Nadzalan[6(ABCDEFG)]
1 ORCID: /0000-0001-7846-0347
Sultan Idris Education University, Faculty of Sports Science and Coaching, Tanjong Malim (Malaysia)
2 ORCID: 0000-0003-1437-0486
Sultan Idris Education University, Faculty of Sports Science and Coaching, Tanjong Malim (Malaysia)
3 ORCID: 0000-0001-8392-8274
Sultan Idris Education University, Faculty of Sports Science and Coaching, Tanjong Malim (Malaysia)
4 ORCID: 0000-0003-3676-5614
Loughborough University, School of Sport, Exercise and Health Sciences, Loughborough (United Kingdom)
5 ORCID: 0000-0002-7817-0574
Sultan Idris Education University, Faculty of Sports Science and Coaching, Tanjong Malim (Malaysia)
6 ORCID: /0000-0002-0621-2245
Sultan Idris Education University, Faculty of Sports Science and Coaching, Tanjong Malim (Malaysia)
Corresponding author: Ali Md Nadzalan, Sultan Idris Education University, Faculty of Sports Science and Coaching, Sultan Azlan Shah Campus, Proton City, 35900 Tanjong Malim, Perak, Malaysia.
e-mail: ali.nadzalan@fsskj.upsi.edu.my, phone: +60195608644

The acute effects of loading used in wearable resistance on kinetics and kinematics during taekwondo axe kick

Submission: 18.02.2022; acceptance: 9.04.2022

Key words: ground reaction force, kicking velocity, kicking time, wearable resistance, specificity

Abstract
Background. Wearable resistance (WR) is used in sports training with the aim of increasing performance by enabling sport-specific movements to occur with additional loading.
Problem and aim. Despite its potential to allow athletes to move more specifically, studies examining WR during kicking in taekwondo are scarce. The purpose of this study is to determine the acute effects of loading in WR on the kinetics and kinematics during taekwondo axe kicks.
Material and methods. Thirty (N=30) university taekwondo athletes have been recruited as participants in this study. Participants performed a middle axe kick with WR loading worn at the lower body (0%, 5%, 10%, and 15% of body mass) during the execution. A high-speed motion capture system was used to analyse kinematic data (kicking velocity and kicking time) while the force plate was used to measure ground reaction force (GRF).
Results. Results showed there was a significant change in kicking kinematics (kicking time was longer and there was a decrease in kicking velocity) as the WR load increased. There was a significant increase of GRF on the supporting leg as WR loads attached increased.
Conclusions. In conclusion, WR loading of 5% body mass and higher at the lower body affected the biomechanics of the middle axe kick. Although mechanically affected the movement, future studies are suggested to investigate the chronic effects of these loading. The implications of this study can be used as a guideline for choosing proper WR loading to be used in training.

For citation – in IPA style:
Mandra J., Noorzaliza O., Nur Ikhwan M., Tan K., Zulezwan A.M., Nadzalan A.M. (2024), *The acute effects of loading used in wearable resistance on kinetics and kinematics during taekwondo axe kick*, "Ido Movement for Culture Journal of Martial Arts Anthropology", vol. 24, no. 1, pp. 1–7; doi: 10.14589/ido.24.1.1.
In other standard – e.g.:
Mandra, J., Noorzaliza, O., Nur Ikhwan, M., Tan, K., Zulezwan, A.M., Nadzalan, A.M. The acute effects of loading used in wearable resistance on kinetics and kinematics during taekwondo axe kick. *Ido Mov Cult J Martial Arts Anthrop*, 2024, 24 (1): 1–7 DOI: 10.14589/ido.24.1.1

Introduction

The axe kicks are commonly used by taekwondo athletes during the tournament especially to attack the opponent. The axe kick is often used to launch an attack used to strike the head to get points as it is the highest point in taekwondo competition rules; thus, it is becoming a popular kick used commonly by fighters [Liu Baocheng *et al.* 1998; Nadzalan *et al.* 2021; Wasik and Shan, 2014]. The execution of these kicks requires the athlete to pull out the leg up in a circular motion, and at the peak height, the heel will be pulled out linearly to the opponent's shoulder or head. Similar to another kick technique within taekwondo, axe kick consists of four stages. The decoy stage is the initial stage, followed by the power load stage, the drive and landing stage, and finally the stabilization stage [Yu *et al.* 2012]. For this reason, the athletes and coaches are advised to select the exercises that perhaps increase the explosive strength at the lower limb. Besides that, coaches or instructors should comprehend the exercises that match those components of taekwondo kicking [Vagner *et al.* 2019]. Resistance training is a kind of training that involves any equipment/tools to become resistant. The traditional methods of resistance training involved individuals going to the gym and lifting weights. Mounting evidence has shown the effectiveness of gym training in improving maximal strength through the increasing of muscle contraction velocity [Topal *et al.* 2011]. The application of resistance training not only affects the muscle size and strength but slows the aging effects on the muscle (sarcopenia) which leads to a decreasing of muscle size and function [Csapo, Alegre 2016; Morse *et al.* 2005; Narici, Maganaris 2007].

However, until now, the issue of the transferability of strength gains achieved from traditional resistance training methods to sport-specific performance is still debated among strength and conditioning coaches, practitioners, and athletes [McGuigan *et al.* 2012; Pareja-Blanco *et al.* 2014]. Traditional resistance training is also preferable to improve muscle strength but the problem is, how we can train the sport most likely depends on the specific movement such as combat sport which is mostly time spent on the specific skill movement [Zemkova, 2018; Zemkova, 2019]. A few strengths and conditioning researchers have argued that a better training transfer can be achieved from exercises that display mechanical specificity to the movement performed in a competition [Moir *et al.* 2018] and specificity of the movement velocity [Pareja-Blanco *et al.* 2014]. Currently, similar to most other sports, strength training protocols for combat sports utilize the normally available weight machines and free weight apart from the most widely used bodyweight strength training [Lenetsky *et al.* 2013; Saraiva *et al.* 2014]. It is thus proposed here that training should utilize loading methods that are more functional, and able to be loaded while performing the actual combat sports movement. Therefore, loadings that permit performers to move freely according to sports movement are suggested.

Wearable resistance training involves an external load being attached to certain segments of the body during various sporting movements and is an example of the application training specificity concept [Dolcetti *et al.* 2019; Macadam *et al.* 2019]. Wearable resistance is used in athletic training with the aim of increasing power output and performance by enabling specific movements to occur with additional loading without adversely affecting the technical execution of the action being performed [Macadam *et al.* 2019]. It is in the form of weighted vests, shorts, arm, and leg sleeves that increased the ability in terms of the movement-specific action (i.e., the external load is applied) and became the popular tool being examined among many sports teams and the individual athlete. The new wearable resistance technologies (i.e., the Lila TM Exogen TM exoskeleton suit) enable much greater customization of load magnitudes, orientations, and locations around the body. This kind of wearable resistance enables sport-specific actions to be performed in an overloaded manner [Macadam *et al.* 2017a]. The study regarding wearable resistance previously involved researchers selecting the loading in the range of 1-10 % of body mass (BM) for determining the effects on physical performances and sports. Thus, through their studies regarding wearable resistance, they had provided the direction of a framework on loading position and particular % of BM. Those findings could be the guidance and references for the practitioner or coaches to adapt within their training program. The selected loading of wearable resistance is very important to investigate the different effects of such weight on certain training or performance within the sport.

Most studies involving WR had been conducted in running, sprinting, and jumping [Feser *et al.* 2021; Macadam *et al.* 2017a] while not many studies had been conducted specifically in Taekwondo. The study by Feser *et al.* [2021], found that the athletes that performed wearable resistance training intervention did not significantly improve or become slowest in the sprint running times or velocity. Based on this, we can see that the attachment of 1% load of wearable resistance is not enough to resist any activity and it is recommended to increase the load percentage that perhaps will give stimulus to the training of the athletes. As a way to enhance knowledge and understanding of WR, it is the aim of this study to determine and evaluate the effects of loading on kinetic and kinematic of axe kick during Taekwondo. 5%, 10% and 15% of body mass were chosen as the loads for us to look at how these loading will affect the movement biomechanics and thus showed us the suitability to be used during a training session. The findings of this study are believed will add knowledge and can become a reference for the selection of loads during WR training.

Materials and methods

Participants

Thirty (n=30) male Taekwondo athletes represented the university (mean ± SD: age: 22.17 ± 1.21 years, body-weight: 72.30 ± 13.31 kg and height: 170.13 ±7.64 cm), familiar while performing the kicking without target (as in this study, there is no target are included), and at least have some knowledge in resistance training were recruited as participants. All participants were free of any injuries to prevent any consequences that lead to an injury afterwards. Participants had filled in the Physical Activity Readiness Questionnaire (PAR-Q) and informed consent. All participants were reminded that their participation in this study is based on volunteerism and they are free to withdraw from the study at any time. This study has obtained approval from the University's Human Research Ethics Committees.

Procedure

The cross-over design, with cross-over and counter-balanced testing methods were used to investigate the effects of wearable resistance loaded with 0%, 5%, 10%, and 15% of the body mass on the biomechanics of axe kick execution.

Figure 1. Location of WR placed on the body

The testing was conducted in the biomechanics laboratory which required the participants to wear the wearable resistance via Lila™ Exogen™ lower body compression sleeves (short and calves) (Figure 1) which allow the combination of 50, 100, and 200g loads to be attached when executing the axe kick with the dominant leg. The test was conducted according to the load whereby each participant completed the axe kick movement starting with without load (0%) followed by the rest between loads 72 hours before proceeding to the next loads (5%, 10%, and 15%) to avoid fatigue among participants. A motion capturing system (Vicon T10s, Oxford Metrics, UK) with six Real-time motion analysis cameras was placed pointed at the participant's testing area where the Tri-axial force platform (BP400600HF-2000 AMTI Inc., USA) device is located. The data was collected during the axe kick from the start position (toe take-off from the ground) to the end position (toe peak height) (Figure 2) while the supporting leg stepped up on the force plate. Analysis of the kicking velocity, and kicking time were interpreted through the Vicon analysis software (Vicon Polygon), while the AMTI's BioAnalysis software was used for the data acquisition of the ground reaction force (GRF).

Statistical Analysis

All statistical analyses were processed using the Statistical Package for the Social Sciences (SPSS, Version24; IBM, Somers, NY, USA). Means and standard deviations were used to represent the centrality and spread of data for all performance measures. The hypotheses of normality and homogeneity of the variance were analyzed via Kolmogorov–Smirnov and Levene tests, respectively. One-way repeated measure analysis of variances (ANOVA) was used to analyses the comparison between the loadings used. An alpha level of 0.05 is set to assess statistical significance for all tests.

Results

Table 1. The mean and standard deviation of kicking velocity and kicking time according to the wearable resistance loads.

Variables	n	WR 0% of BM (without WR)	WR 5% of BM	WR 10% of BM	WR 15% of BM
Kicking Velocity (ms^{-1})	30	5.53 ± 0.48*	5.22 ± 0.57**	4.93 ± 0.54#	4.65 ± 0.61##
Kicking Time (s)	30	0.39 ± 0.03*	0.41 ± 0.04**	0.43 ± 0.04#	0.45 ± 0.06##

* Velocity significantly different from 5%, 10% and 15% WR.
** Velocity significantly different from 0%, 10% and 15% WR.
# Velocity significantly different from 0%, 5%, and 15% WR.
Significantly different from 0%, 5% and 10% WR. (p <.05).

Table 1 includes the results of kicking velocity and kicking time during the execution of the axe kick with loading (0%, 5%, 10% and 15% of body mass). Results showed that there was a significant main effect of wearable resistance loads on kicking time, $F(3, 87) = 25.22$, $p = .000$, $\eta p2 = .47$. The result of kicking time of the participants without load was significantly shorter com-

Figure 2. Sequences of axe kick

pared to the participants with WR 5%, 10% and 15% of body mass, $p < 0.01$. The kicking time of the participants loaded with WR5% was also significantly shorter compared to the participants loaded with WR 10% and WR 10% of BM, $p < 0.05$. A similar result also occurred in participants with WR 10%, in which the kicking time was significantly shorter compared to the participants with load WR 15%, $p < 0.05$. This result explained that the kicking time also became slower continuously as the WR loads attached during the axe kick execution increased.

A significant main effect was also found on the kicking velocity, $F (3, 87) = 35.97$, $p = .000$, $\eta p2 = .55$). The result showed that the kicking velocity of the participants was significantly higher when without load compared to the participant loaded with WR 5%, 10% and 15% of body mass (BM), $p < 0.01$. The kicking velocity of participants loaded with WR 5% of BM was also significantly higher compared to the participants loaded with WR 10% and 15% of BM and participants loaded with WR 15% of BM, $p < 0.05$. Besides, the kicking velocity of participants loaded with WR 10% of BM was significantly higher compared to the participants loaded with WR 15% of BM. This result showed that the kicking velocity is slower as the WR loads attached are increased.

Table 2. The mean and standard deviation of the GRF according to the wearable resistance loads

Variables	n	WR 0% of BM	WR 5% of BM	WR 10% of BM	WR 15% of BM
GRF (N)	30	905.47 ± 157.47*	921.37 ± 157.81	926.24 ± 164.20	930.09 ± 160.40

* GRF significantly different from 10% and 15% WR.

Table 2 includes the results of the GRF during the execution of the axe kick with loading (0%, 5%, 10% and 15% of body mass). The results of the one-way repeated measures ANOVA showed that there was a significant main effect of wearable resistance loads on the GRF for the supporting leg, $F (3, 87) = 3.72$, $p = .014$, $\eta p2 = .14$. The result of GRF of the participants with WR 0% was lower but not significantly when compared to the GRF of participants with WR 5%, $p > 0.05$. However, the result was significantly lower when compared to the GRF of the participants with WR 10% and participants with WR 15%, $p < 0.05$. The GRF result of the participants with WR 5% is not significantly lower compared to the GRF of the participants with WR 10% and participants with 15%, $p > 0.05$. Besides that, the GRF of participants with WR 10% was also not significantly lower when compared to the GRF of participants with WR 15%, $p > 0.05$. The result acquired indicated that the GRF of the participant increased uniformly as the WR loads attached are increased during the axe kick execution.

Discussion

The purpose of this study was to compare the acute effects of wearable resistance loading during taekwondo axe kicks where data were compared between selected loads of (0%, 5%, 10%, and 15% of body mass) attached to the lower extremities. The analysis of kicking time, kicking velocity and ground reaction force (GRF) were acquired from the data. The analysis demonstrated that kicking time is 5.13% slower when the axe kick is executed with $5\%_{bm}$ WR, 10.26% slower with $10\%_{bm}$ WR and 15.38% slower with $15\%_{bm}$ WR implementation when compared to no WR implementation.

WR application alters segment inertial properties and as such can be considered an organismic constraint [Field *et al.* 2019; Martin, Cavanagh 1990]. A prolonged adaptation toward the usage of WR in training would ultimately be a useful stimulus to develop an adapted movement behavior among athletes in preparation for changing real live situation during match games which could be an advantage in terms of performance deliverance. The kicking time is relatively slower with each increasing WR load. However, the intensity and the force applied are the same with each trial. An adaptation to a heavier load will result in a faster kicking time when the load is no longer an issue.

Results also showed a decrease of 5.56% (5% BM), 10.85% (10% BM) and 15.91% (15% BM) in kicking velocity when compared to without WR. The kicking velocity is influenced by the kicking time meaning that, to achieve a better kicking velocity, the kicking time of the participants should be minimal. When WR loads were applied to their lower body, the loads attached gave resistance at the leg of the participant which detained their kicking time during the execution. In this case, the kicking velocity of the participants decreases directly proportional to the WR loads. The decrease in velocity is seen to be gradually slower with smaller changes in WR loading which will in turn applied to the physiological adaptation. Compared to traditional load which is far heavier or has a big difference between weight changes, which might fatigue the muscle faster than the adaptation to occur. Minimal changes in load give spaces for the kinematics to adapt to the movement according to the load and this will possibly minimize errors in joint movement rather than big changes in load which could end up failing the mechanism of movement.

Specific movement speed is one of the most important considerations for training transfer. With WR and the ability to load very lightly, the coach doesn't have to be concerned with getting transference so much as blocking it. Maintaining the movement speeds, in this case, the kicking velocity during training close to competition is more likely beneficial. For example, Macadam *et al.* [2017b], and Simperingham, Cronin [2014] found that the magnitude of loading was found to only decrease peak velocity during the acceleration phase by -2.3% and the maximal velocity phase by -5.3% for sprint trained individuals when using 5% BM WR attached across the thigh and shank. Therefore, progressing up to 5% BM with a whole leg loading scheme would safely keep athletes within competition speeds. As for this study which involved kicking, we used up to 15% of BW WR attached and the maximal velocity decrease accounted for 15.91% which is much slower compared to only 5% of BW WR.

Results also showed an increase of 1.76% (5% BM), 2.29% (10% BM) and 2.72% (15% BM) in GRF of the supporting leg when compared to without WR. In these circumstances, participants have to maintain their stance balancing on the supporting leg to overcome the WR loads applied on the lower body. The WR loads affect the stability of the participants where they need to exert more force on the ground and through their core muscle in order to maintain their balance and transfer the force efficiently during the kicking movement. It can be seen that only 2.72% increase in GRF were obtained when 15% BM WR were used. This probably indicate that the WR load does not really give a large effect on the force exerted on the ground during kicking movement.

For movement such as kicking, a few hundred grams placed strategically on the lower limbs to target some aspect of an athlete's specific game speed could have substantial physiological and psychological effects on the athlete. The study by Bennett *et al.* [2009] and Macadam *et al.* [2017b] have investigated loads as small as 3% BM, attached on the thigh and shank, which was found to significantly overload aspects of the sprint running movement pattern and mechanical output capabilities of the athlete [Macadam *et al.* 2017b; Simperingham, Cronin 2014]. Given this piece of information, the athlete needs to be overloaded in a systematic and safe manner. With 5% to 15% of BW WR application, the increase in force output is gradually increased.

The objective for the development of WR technology has been to allow a relevant load to be applied directly to the body that will then directly stress specific movements under the specific demands of an actual sport and competitive environment, with little compromise to the speed of motion, range of motion and specific skill. Nowhere is this more important than in the realm of speed and agility training where even slight modifications in these parameters greatly reduce improvement in actual competition. The application of WR in the movement of kicking like in this study is significantly important to deliver an optimum training mechanism which could then transfer to competition.

Conclusions

In the conclusion, wearing the lower body loading with different loads (0%, 5%, 10%, and 15% of the body mass) had an acute effect on the biomechanics of the middle axe kick in taekwondo. The wearable resistance loads started with 5% and above mechanically affected the movement of the participants during the execution of the taekwondo axe kick. The implications of this study can be used as a guideline for choosing proper WR loading to be used in training. However, there are several areas that desire further research such as chronic study which can show the true potential for adaptation of the wearable resistance loading. In this study, the skill was performed only using the dominant leg. In the actual performance, the kick may be executed with either a dominant or non-dominant leg. Besides that, the GRF of both legs should also be considered in order to further understand the effect of wearable resistance.

References

1. Bennett J.P., Sayers M.G., Burkett, B.J. (2009), *The impact of lower extremity mass and inertia manipulation on sprint kinematics,* "The Journal of Strength & Conditioning Research", vol. 23, pp. 2542-2547.
2. Csapo R., Alegre L. (2016), *Effects of resistance training with moderate vs heavy loads on muscle mass and strength in the elderly: A meta-analysis*, "Scandinavian Journal of Medicine & Science in Sports", vol. 26, pp. 995-1006.

3. Dolcetti J.C., Cronin J.B., Macadam P., Feser E.H. (2019), *Wearable resistance training for speed and agility,* "Strength & Conditioning Journal", vol. 41, pp. 105-111.
4. Feser E.H., Bayne H. Loubser I., Bezodis N.E., Cronin J.B. (2021), *Wearable resistance sprint running is superior to training with no load for retaining performance in pre-season training for rugby athletes*, "European Journal of Sport Science", vol. 21, pp. 967-975.
5. Field A.P., Gill N., Macadam P., Plews D. (2019), *Acute metabolic changes with thigh-positioned wearable resistances during submaximal running in endurance-trained runners,* "Sports", vol. 7, pp. 187.
6. Lenetsky S., Harris N., Brughelli M. (2013), *Assessment and contributors of punching forces in combat sports athletes: Implications for strength and conditioning*, "Strength & Conditioning Journal", vol. 35, pp. 1-7.
7. Liu Baocheng, Zhao Qiurong & Fan L. (1998), *The technology analysis of 1997 "Kang Cup" National Taekwondo Championship,* "Journal of Xian Sports Institute", vol. 15, pp. 37-41.
8. Macadam P., Cronin J.B., Simperingham K.D. (2017a), *The effects of wearable resistance training on metabolic, kinematic and kinetic variables during walking, running, sprint running and jumping: A systematic review*, "Sports Medicine", vol. 47, pp. 887-906.
9. Macadam P., Simperingham K.D., Cronin, J.B. (2017b), *Acute kinematic and kinetic adaptations to wearable resistance during sprint acceleration,* "The Journal of Strength & Conditioning Research", vol. 31, pp. 1297-1304.
10. Macadam P., Simperingham K.D., Cronin J.B. (2019), *Forearm wearable resistance effects on sprint kinematics and kinetics*, "Journal of Science and Medicine in Sport", vol. 22, pp. 348-352.
11. Martin P.E., Cavanagh P.R. (1990), *Segment interactions within the swing leg during unloaded and loaded running,* "Journal of Biomechanics", vol. 23, pp. 529-536.
12. Mcguigan M.R., Wright G.A., Fleck S.J. (2012), *Strength training for athletes: does it really help sports performance?*, "International Journal of Sports Physiology and Performance", vol. 7, pp. 2-5.
13. Moir G.L., Brimmer S.M., Snyder B.W., Connaboy C., Lamont, H.S. (2018), *Mechanical limitations to sprinting and biomechanical solutions: a constraints-led framework for the incorporation of resistance training to develop sprinting speed,* "Strength & Conditioning Journal", vol. 40, pp. 47-67.
14. Morse C.I., Thom J.M., Reeves, N.D., Birch K.M., Narici M.V. (2005), *In vivo physiological cross-sectional area and specific force are reduced in the gastrocnemius of elderly men*, "Journal of Applied Physiology", vol. 99, pp. 1050-1055.
15. Nadzalan A.M., Janep M., Jahizi A.A.M, Malek N.F.A., Ibrahim T.M.S.T., Mohamad N.I. (2021), *The influence of wearable resistance loading on taekwondo axe kick kinematics among elite taekwondo athletes*, "International Journal of Human Movement and Sports Sciences", vol. 9, pp. 893-898.
16. Narici M.V., Maganaris C.N. (2007), *Plasticity of the muscle-tendon complex with disuse and aging*, "Exercise and Sport Sciences Reviews", vol. 35, pp. 126-134.
17. Pareja-Blanco F., Rodriguez-Rosell D., Sanchez-Medina L., Gorostiaga, E., Gonzalez-Badillo J. (2014), *Effect of movement velocity during resistance training on neuromuscular performance*, "International Journal of Sports Medicine", vol. 35, pp. 916-924.
18. Saraiva A.R., Reis V.M., Costa P.B., Bentes C.M., e Silva G.V.C., Novaes J.S. (2014), *Chronic effects of different resistance training exercise orders on flexibility in elite judo athletes*, "Journal of Human Kinetics", vol. 40, pp. 129-137.
19. Simperingham K., Cronin J. (2014), C*hanges in sprint kinematics and kinetics with upper body loading and lower body loading using exogen exoskeletons: A pilot study*, "Journal of Australian Strength and Conditioning", vol. 22, pp. 69-72.
20. Topal V., Ramazanoglu N., Yilmaz S., Camliguney A.F., Kaya F. (2011), *The effect of resistance training with elastic bands on strike force at Taekwondo*, "American International Journal of Contemporary Research", vol. 1, pp. 140-144.
21. Vagner M., Malecek J., Tomsovsky L., Kubovy P., Levitova A., Stastny P. (2019), *Isokinetic strength of rotators, flexors and hip extensors is strongly related to front kick dynamics in military professionals,* "Journal of Human Kinetics", vol. 68, pp. 145-155.
22. Wasik J., Shan G. (2014), *Factors influencing the effectiveness of axe kick in taekwon-do,* "Archives of Budo", vol. 10, pp. 29-36.
23. Ying F., Hua S. (2009), *The analysis and research of the competition rules of the taekwondo in 2008,* "Martial Arts and Professional Boxing Teaching", vol. 9, pp. 86.
24. Yu D., Yu Y., Wilde B., Shan G. (2012), *Biomechanical characteristics of the Axe Kick in Tae Kwon-Do*, "Archives of Budo", vol. 8, pp. 213-218.
25. Zemkova E. (2019), *Reliability of a novel method assessing muscle power and velocity during seated trunk rotations*, "Physical Activity Review", vol. 7, pp. 1-8.
26. Zemkova E. (2018), *Science and practice of core stability and strength testing*, "Physical Activity Review", vol. 6, pp. 181-193.

Gwałtowny wpływ obciążenia stosowanego w strojach sportowych z obciążnikach na kinetykę i kinematykę podczas kopnięcia opadającego (*axe kick*) w taekwondo

Słowa kluczowe: siła reakcji podłoża, prędkość kopnięcia, czas kopnięcia, odporność na zużycie, specyfika

Streszczenie

Tło. Strój sportowy z obciążnikami (WR) jest stosowany w treningu sportowym w celu zwiększenia wydajności poprzez umożliwienie wykonywania ruchów specyficznych dla sportu przy dodatkowym obciążeniu.

Problem i cel. Pomimo możliwości umożliwienia sportowcom poruszania się w bardziej szczególny sposób, badania analizujące WR podczas kopnięć w taekwondo są rzadkie. Celem

niniejszego badania było określenie gwałtownego wpływu stoju z obciążnikami na kinetykę i kinematykę podczas kopnięcia opadającego w taekwondo.
Materiał i metody. Trzydziestu (N = 30) uniwersyteckich zawodników taekwondo zostało zrekrutowanych jako uczestnicy tego badania. Wykonywali oni środkowe kopnięcie opadające z obciążeniem WR noszonym w dolnej części ciała (0%, 5%, 10% i 15% masy ciała). Do analizy danych kinematycznych (prędkość kopnięcia i czas kopnięcia) wykorzystano szybki system przechwytywania ruchu, natomiast do pomiaru siły reakcji podłoża (GRF) użyto płyty siłowej.
Wyniki. Wyniki pokazały, że nastąpiła znacząca zmiana w kinematyce kopnięć (czas kopnięcia był dłuższy, prędkość kopnięcia spadła) wraz ze wzrostem obciążenia WR. Zaobserwowano znaczący wzrost GRF na nodze podpierającej wraz ze wzrostem obciążenia WR.
Wnioski. Podsumowując, obciążenie WR wynoszące 5% masy ciała i więcej w dolnej części ciała wpłynęło na biomechanikę środkowego kopnięcia opadającego. Chociaż mechanicznie wpłynęło to na ruch, sugeruje się przyszłe badania w celu zbadania przewlekłych skutków tych obciążeń. Implikacje tego badania mogą być wykorzystane jako wytyczne do wyboru odpowiedniego obciążenia WR do wykorzystania w treningu.