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Original Article

Beneficial effects of Tualang honey supplementation and countermovement jumping exercise on muscular performance among inactive young males

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Abstract:
The combined effects of Malaysian Tualang honey (TH) and countermovement jumping exercise on muscular performance among inactive young males were explored in this study. Methods: A total of 40 participants were recruited and randomly assigned into four groups, i.e., control (C), honey (H), jumping (J), and combined jumping with honey (JH) groups. The countermovement jumping exercise consisted of 2 sessions/day, 3 sessions/week for 6 weeks. Participants in H and JH groups consumed 20 g of TH in the morning daily for 6 weeks. Pre- and post-tests were conducted on participant's anthropometric parameters, vertical jump height, standing long jump distance, isokinetic muscular peak torque (strength), and average power on the dominant leg. Two-way mixed ANOVA was used for statistical analysis. Results: In J and JH groups, there was a significant increase by 7.75% in the J group and 16.80% in the JH group in height of the vertical jump. There was also a significant increase ($p < 0.05$) in the distance of standing long jump in H, J, and JH groups. Among all, JH group showed the highest improvement compared to other groups. Regarding isokinetic muscular performance parameters, JH group showed a significant increase ($p < 0.05$) in knee extension peak torque at $300^o s^{-1}$, flexion peak torque at $300^o s^{-1}$, extension average power at $60^o s^{-1}$, extension average power at $300^o s^{-1}$, flexion average power at $60^o s^{-1}$, and flexion average power at $300^o s^{-1}$. In the J group, knee extension average power at $300^o s^{-1}$ significantly increased. Conclusion: Combination of countermovement jumping exercise with TH increases muscular strength and power in young males.
Key Words: Glucose, force, peak torque, vertical jump, phenolic

Introduction

Tualang honey (TH), or its scientific name *Koompassia excelsa* in technical terms, is multi-floral honey made by *Apis dorsata*, a rock bee species rock bee species which found on the Tualang treess (Azman et al., 2015). Honey has reported to improve bone mineral density and promote calcium absorption in rats, indicating that it may have positive effects on animals (Chepulis and Starkey, 2008; Ariefdjohan et al., 2008) and human bones (Zuhri et al., 2020). Several studies have performed to learn the TH supplementation effects on bones and reproductive hormones in rats (Ooi et al., 2014; Mosavat et al., 2014; Tavafzadeh et al., 2011). In addition, the combination of TH and aerobic dance exercise exhibited beneficial effects on lower limb isokinetic average power compared to TH alone and the results of control groups in humans (Rahim et al., 2016). However, no studies conducted on the combined effect of TH and countermovement jumping exercise on muscular performance in humans.

Honey's impact on exercise performance, particularly endurance performance, is believed to be attributed to its carbohydrate (CHO) content. Consuming CHO during extended activity avoids hypoglycemia, promotes high rates of CHO oxidation, and boosts endurance. Only a few research have indicated that taking relatively small amounts of CHO (20 g/h) is sufficient to produce favourable performance effects (Menzies et al., 2020; Newell et al., 2018). In contrast, exogenous CHO consumption has demonstrated to have no effect on endurance performance (Jeukendrup & Jentjens, 2000). In their review, they recommend a maximum CHO consumption of 60 g/h during exercise. Other than CHO, honey also contains of

Regarding muscular performance, muscular strength and power are vital for humans to conduct their daily activities efficiently. Muscular strength is the ability of a muscle or a group of muscles to produce force against an external resistance (Moir et al., 2012). Muscular power is the ability to contract muscle with speed and force in one explosive act (Maffiuletti et al., 2016). Greater muscular strength allows an individual to potentiate earlier to a greater extent, also decreases the risk of injury (Suchomel et al., 2016).

Jumping, hopping, skipping, and bounding are examples of plyometric exercises that are used to improve dynamic muscle performance. As a result, plyometric exercises are commonly used to improve dynamic athletic performance, such as vertical jump ability, speed, agility, and lower-extremity muscle activation. These exercises, which exploits the muscle unit's stretch-shortening cycle, have consistently been shown to improve

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muscle force and power generation (Singh et al., 2013; Thakur et al 2016). The process related with to stretch-shortening cycle (SSC) could increase and enables the elasticity and the stretch reflex activities and improve muscle output. (Fukutani et al, 2021). Sozbir (2016) has reported that high impact exercise may strengthen the muscle and produce peak forces. In addition, in the previous study by Freitas-Junior et al. (2020) who studied the effects of countermovement jumping exercises among volleyball player for 6 weeks found that by performing repeated effort of jumping may have contributed to the ability of the athletes to support higher external loads during training and games.

Vertical jumping is a fundamental component of many sports and also may be predictive of performance in other sports in which it is not the primary component. The effects of plyometric exercise on vertical jump performance have been widely researched. A vertical jump that begins with a preceding downward movement (eccentric muscle contraction) and finishes with an upward movement from a static position is known as a countermovement jump (concentric muscle contraction). This rapid combination of eccentric and concentric muscular activity involves the stretch-shortening cycle (Arazi et al., 2016; Thakur et al., 2016).

Among the supplements tested, a previous study has shown that caffeine provides acute beneficial effects on muscle strength (Chen et al., 2019), whereas in long-term consumption of creatine (Tomcik et al., 2018) and protein (Loenneke et al., 2016) seems to increase muscle mass and strength. Some studies reported that branched-chain amino acids (AbuMoh'd et al., 2020) and most antioxidants (Dutra et al., 2018) were the most popular supplements that produced positive impacts on sport performance and physiological demands. The impact on honey in combination with jumping exercise on isokinetic strength and power in young males is currently unknown. Therefore, this study was performed to fill in the knowledge gap.

Materials and methods

Participants and recruitment

Forty participant volunteers to participate in this intervention study. Before signing the consent form, participants had been explained regarding the procedures, the experimental protocol and possible risks. The inclusion criterias include, healthy yang male aged between 18 to 24 years old, physically inactive, and did exercise less than twice per week. However, the participants' who involved in training periodically or will taking part in the competition got health problems such as high blood pressure, stroke, diabetes, and asthma, injured on the lower limb in the past 6 months, taking honey or any nutritional product as regular supplement and on under drug prescription

Participants from Universiti Sains Malaysia (USM) and people staying nearby USM were recruited by advertising this study on posters and flyers. Some of them were approach through email and face-to face as well. After this study got an approval from USM Human Research Ethic Committees (USM/JEPeM/18020156), data collection was started after all the participants had signed a consent form.

Study Design

A randomised controlled trial study was developed by block randomisation by using computer-based random number (www.randomization.com). This study also applied an opportunistic sampling method. Participants were randomly assigned into four groups which are physically inactive control group (C), Honey supplementation (H), Jumping exercise (J) and Combined honey supplementation with jumping exercise (JH) groups. The group distribution also was based on their age and body weight. The participants in J and JH groups performed countermovement jumping exercises twice per day, 3 times per week for 6 weeks but those in C and H groups did not prescribe with any kind of exercises. Every morning, 8: 00 a.m. participants in H and JH groups drank 20 g of TH. Participants' muscular performance was determined to identify muscular strength and power using an isokinetic dynamometer machine (BIODEX Multi – Joint System 3 Pro, New York), standing long jump test, and vertical jump test at pre- and post-tests. For statistical analysis, to identify the significant differences between and within groups, two-way mixed ANOVA was performed and followed by post-hoc Bonferroni's test to determine the significant differences found in two-way mixed ANOVA. The results were reported in mean and standard deviation for all data.

Results

Participant's Anthropometric Characteristics and Jumping Height

A total of 40 participants completed the study. The baseline data for all the participants includes mean age of 22.23 ± 1.27 years, mean body weight of 61.99 ± 9.79 kg, mean body height of 168.73 ± 5.92 cm, and mean body mass index (BMI) of 21.73 ± 2.64 kg.m^{-2}. The average mean age for each group weas measured and found that there were no significant differences at the baseline level. The mean age of the participants was 22.9 ± 1.4 years in the C, 21.8 ± 1.8 years in H , 22.2 ± 1.0 years in J, and 22.0 ± 0.5 years in JH groups. In addition, pre-test body weight in C, H, J, and JH was 61.5 ± 11.2, 60.6 ± 12.6, 62.9 ± 7.5, and 62.9 ± 8.3 kg, respectively; meanwhile, the mean body height in C, H, J, and JH was 168.7 ± 6.8, 167.8 ± 8.1, 169.7 ± 4.2, and 168.7 ± 4.4 cm, respectively. The pre-test values showed no significant differences in mean body weight and mean body height on all groups.

Vertical jump height

The mean and percentage change of vertical jump height during pre- and post-test were presented in Figure 1. The figure shows a significant increase in vertical jump height in J ($p = 0.017$) group by 7.75% and JH ($p < 0.001$) group by 16.80% after 6 weeks of intervention. Furthermore, during post-test, among all the groups JH group showed a significantly higher improvement value compared to C ($p = 0.040$) and H ($p = 0.043$) groups. In contrast, C group showed reduction in 2.56% after intervention period and no significant changes for H group.

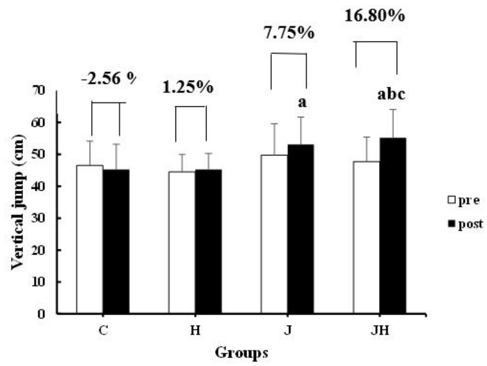

Figure 1. Vertical jump height during pre- and post-test
Data are presented as mean ± standard deviation, n = 10 participants per group
[a], $p < 0.05$ significantly different compared pre-test
[b], $p < 0.05$ significantly different compared C group during post-test
[c], $p < 0.05$ significantly different compared tom H group during post-test

Standing Long Jump Distance

Figure 2 shows a significant increase in H ($p = 0.029$), J ($p = 0.001$), and JH ($p < 0.001$) groups after 6 weeks intervention. Standing long jump distance showed higher percentage change by 7.27% and 11.75% in J and JH groups respectively. Moreover, in comparison with C group, there was a significantly greater ($p = 0.040$) distance of standing long jump in the J group during the post-test. Generally, the J and JH group showed the higher progression compared to C and H groups.

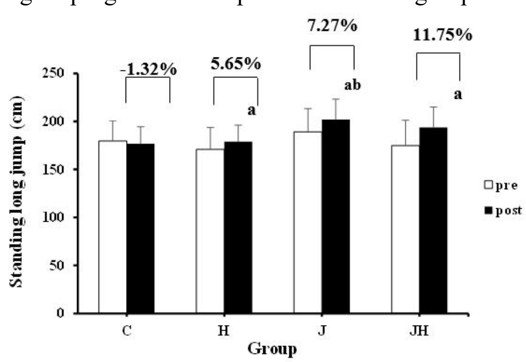

Figure 2. Standing long jump distance during pre-test and post-test
Data are presented as mean ± standard deviation, n = 10 participants per group
[a], $p < 0.05$ significantly different compared to pre-test
[b], $p < 0.05$ significantly different compared to C group during post-test

Peak Torque of Knee Extension at 60^o s^{-1}

Table 1 shows that there was a significant reduction in the C group ($p = 0.021$) by 6.67% after 6 weeks intervention. Furthermore, J and JH groups showed positive percentage changes of mean of peak torque of knee extension at 60^o s^{-1} by 4.65% and 6.11% respectively.

Peak Torque of Knee Extension at 300^{o}s^{-1}

The mean peak torque of knee extension at 300^{o}s^{-1} for all groups during pre- and post-test and percentage change are presented in Table 1. A significant rise ($p = 0.025$) was showed in JH group during post-test. Generally, all groups showed an improvement in the mean peak torque of knee extension at 300^{o}s^{-1}, but no significant different except for JH group, and the JH group recorded the highest percentage change of 11.27%.

Peak Torque of Knee Flexion at 60 $^{o}s^{-1}$

Table 1 also present the mean peak torque of knee flexion at $60^{o}s^{-1}$ for C, H, J and JH groups during pre- and post-test and percentage change. Overall, C and J group showed reduction in peak torque of knee flexion at $60\,^{o}s^{-1}$. However, H and JH groups showed an enhancement in percentage changes after 6 weeks by 9.61% and 15.08% respectively although there was no significant difference between and within groups.

Peak Torque of Knee Flexion at 300 $^{o}s^{-1}$

The percentage of change of the mean peak torque of knee flexion at $300^{o}s^{-1}$ for all groups during pre- and post-test can be referred in Table 1. After 6 weeks of intervention, the highest increment was showed in JH group (p = 0.008) by 14.96%. Meanwhile, other groups also showed an increase in percentage change of the mean peak torque of knee flexion at $300^{o}s^{-1}$ even though in statistical analysis showed no significant different.

Table 1. Mean peak torque (strength) for all groups during pre- and post-test

Peak torque	Groups			
	C	H	J	JH
Peak torque of knee extension $60s^{-1}$ (Nm)				
Pre	174.64 ± 42.97	152.99 ± 18.35	184.60 ± 52.05	175.83 ± 37.17
Post	157.48 ± 20.47[a]	161.43 ± 36.54	182.94 ± 58.33	184.73 ± 31.39
Percentage changes (%)	-6.67%	4.65%	-0.80%	6.11%
Peak torque of knee extension of $300s^{-1}$ (Nm)				
Pre	96.78 ± 21.21	87.27 ± 11.46	113.31± 26.77	99.91 ± 14.94
Post	101.54 ± 19.98	94.39 ± 18.21	114.28 ± 26.13	109.27 ± 10.38[a]
Percentage changes (%)	6.45%	8.14%	1.58%	11.27%
Peak torque of knee flexion $60s^{-1}$ (Nm)				
Pre	77.25 ± 19.78	75.13 ± 10.89	94.21 ± 21.06	79.16 ± 24.44
Post	74.88 ± 21.66	81.92 ± 13.48	91.12 ± 25.88	85.80 ± 13.97
Percentage changes (%)	-2.99%	9.61%	-2.93%	15.08%
Peak torque of knee flexion $300s^{-1}$ (Nm)				
Pre	77.17 ± 12.92	70.20 ± 14.40	81.43 ± 16.31	78.72 ± 13.35
Post	83.44 ± 13.53	72.96 ± 12.23	81.20 ± 14.92	88.40 ± 12.14[a]
Percentage changes (%)	9.76%	4.79%	0.38%	14.96%

Data are presented as mean ± standard deviation (SD), n = 10 participants per group
[a], $p < 0.05$ significantly different compared to the pre-test

Average Power of Knee Extension at 60 $^{o}s^{-1}$

Table 2 presents the mean of average power of knee extension at 60^{o} s^{-1} of C, H, J and JH groups and percentage changes. Among all groups JH group showed the highest percentage changes of the mean average power of knee extension at 60^{o} s^{-1} by 23.24%. In addition, there was also a significant value in the JH group (p = 0.021) after 6 weeks of intervention.

Average Power of Knee Extension at 300 $^{o}s^{-1}$

The mean average power of knee extension is at $300^{o}s^{-1}$ during the pre- and post-test, and percentage change for C, H, J and JH groups are demonstrated in Table 2. There was a significant increase in J (p = 0.024) and JH (0.001) groups after 6 weeks of intervention with 11.68% and 21.33% respectively. In addition, the J group also showed a significantly greater value (p = 0.024) compared to the H group. Generally, the results showed positive increase in changes of the mean average power of knee extension at $300^{o}s^{-1}$ for all groups, but the JH group recorded the highest percentage of 21.33%.

Average Power of Knee Flexion at $60^{o}s^{-1}$

Table 2 displays the mean average power of knee flexion at $60^{o}s^{-1}$ for all groups during pre- and post-test and percentage change for all groups. A significant increase (p = 0.022) was found in the JH group during post-test after 6 weeks of intervention. More than 50% increment was recorded in the JH group followed by H and J group. Meanwhile, C group showed the lowest in percentage change of the mean average power of knee flexion at $60^{o}s^{-1}$

Average Power of Knee Flexion at $300^{o}s^{-1}$

The mean average power of knee flexion is at $300^{o}s^{-1}$ during the pre- and post-test, and percentage change for all groups are tabulated in Table 2. After 6 weeks of intervention, there was a significant increase (p = 0.022) in the JH at post-test. Additionally, the JH group showed the highest improvement in percentage change of the mean average power of knee flexion at $300^{o}s^{-1}$ of 26.48%.

Table 2. Mean average power for all groups during pre- and post-test

Average Power	Groups			
	C	H	J	JH
Average power (Watt) of knee extension $60s^{-1}$ at pre- and post-tests				
Pre	104.50 ± 35.10	96.56 ± 12.92	119.49 ± 31.96	106.35 ± 34.15
Post	102.00 ± 17.90	104.34 ± 27.70	121.47 ± 32.52	121.47 ± 23.43[a]
Percentage changes (%)	-2.39%	7.17%	2.48%	23.24%
Average power (Watt) of knee extension $300s^{-1}$ at pre- and post-tests				
Pre	216.31 ± 61.55	188.81 ± 37.59	255.07 ± 75.91	222.90 ± 48.10
Post	216.78 ± 47.77	208.66 ± 52.70	280.10 ± 68.98[ac]	262.00 ± 31.66[a]
Percentage changes (%)	0.22%	10.33%	11.68%	21.33%
Average power (Watt) of knee flexion $60s^{-1}$ at pre and post-tests				
Pre	50.30 ± 22.21	48.67 ± 6.30	64.16 ± 19.93	53.76 ± 26.07
Post	51.17 ± 15.90	56.54 ± 10.22	68.54 ± 18.89	63.65 ± 13.11[a]
Percentage changes (%)	1.72%	17.18%	8.60%	54.71%
Average power (Watt) of knee flexion $300s^{-1}$ at pre- and post-tests				
Pre	121.98 ± 30.92	104.70 ± 40.68	137.34 ± 43.54	120.67 ± 41.62
Post	126.59 ± 30.64	122.36 ± 38.79	145.97 ± 32.28	141.68 ± 31.79[a]
Percentage changes (%)	7.31%	19.80%	9.82%	26.48%

Data are presented as mean ± standard deviation (SD), n = 10 participants per group
[a], $p < 0.05$ significantly different compared to pre-test
[c], $p < 0.05$ significantly different compared to H group during post-test

Discussion

The major findings in this present study were significantly increased ($p < 0.05$) in height of the vertical jump, the distance of standing long jump and isokinetic muscular performance after ingestion of 20g of TH daily and combined with countermovement jumping exercise 3 times per week for 6 weeks. Based on the statistical analysis, the results showed a significant value ($p < 0.005$) of vertical jumping height in J and JH groups at post-test compared to pre-test. Nevertheless, only JH groups demonstrated significant higher ($p < 0.05$) vertical jumping height compared to C and H groups during post-test. These results imply that J and JH can significantly increase muscular jump explosive power. Furthermore, combined jumping exercise with honey supplementation (JH) may stimulate a beneficial effect on increasing muscular jump explosive power than jumping exercise alone (J).

The results of this study on the increase in jumping height with physical training were similar to those of a study conducted by Fatouros et al. (2000), which studied whether select variables of vertical leaping performance can be improved by plyometric training alone or in combination with weight training. Their results indicate that 12 weeks of plyometric training involving jumping movements can improve the height of the vertical jump, but the combination of plyometric training with weight training is even more beneficial. A variety of training approaches can be used to improve all aspects of muscle power and strength (Williams et al, 2017).

Comparison results of the previous study with this study shows that countermovement jumping exercise can increase muscular jumping explosive power in young males within a short period, i.e., 6 weeks compared to 12 weeks of plyometric training and weight training. In addition, the combination of countermovement jumping exercise and Tualang honey supplementation which was JH group may elicit higher effects on increasing muscular jumping explosive power than jumping exercise alone in J group.

Regarding standing long jump distance, a significant greater distance ($p < 0.05$) was recorded in J group compared to C group at post-test. Morriss et al.(2001) investigated the effects of a 6-week isokinetic training programme on quadriceps and hamstrings peak torque (PT) and standing long jump (SLJ) performance and found no significant improvements in hamstring PT and SLJ performance. These results imply that countermovement jumping exercise may be more effective than an isokinetic training program at increasing muscular explosive jump power. The difference between the results of Morriss et al. (2001) and those obtained in this study is that the movement and muscles (quadriceps and hamstring) involved in countermovement jumping exercise in this study are similar to those involved in standing long jump, which may be an advantage for increasing jumping distance. Nevertheless, the isokinetic training used in Morriss et al. (2001) did not provide this advantage.

The present findings also showed either with honey and exercise combination or honey alone could increase standing long jump distance after 6 weeks. This observation was not consistent with a previous study by Rahim et al. (2016), who examined muscular performance in adult women. They discovered no discernible improvements in physical strength or power in the H group.. However, a better effect on muscular power and strength was observed in participants when honey supplementation combined with aerobic dance exercise (HEx) rather than when consuming honey alone (H). Additional nutrient intake and extra calories from honey allow meeting body demands (McNaughton et al., 2011). Honey, which contains high carbohydrates (such as glucose, fructose, and sucrose), is speculated to raise participants' energy levels and increase muscular explosive jump power.It is also speculated that the highest percentage increase in muscular explosive jump power (+11.75%) in JH may be due to the synergistic effects of countermovement jumping exercise and TH supplementation.

This study showed that out of 8 measured isokinetic muscular performance parameters in JH group, 6 parameters significantly increased. The increase was observed in knee extension and flexion peak torque at 300°s^{-1}, extension average power at 60°s^{-1} and 300°s^{-1}, and flexion average power at 60°s^{-1} and 300°s^{-1}. Out of 8 measured isokinetic muscular performance parameters on the J group, only 1 parameter significantly increased, i.e., knee extension average power at 300°s^{-1}. In the H group alone, none of the measured isokinetic muscular performance parameters increased significantly.

In this study, JH group performed significant progression in muscular peak torque and average power compared to the J group. In contrast, the previous study by Chen and research team (2016) reported that the significant changes ($p < 0.05$) in isokinetic muscular strength and power not only can be seen in combined group (resistance training combined with *Lignosus rhinocerotis* supplementation) but also had changes in exercise group without supplementation group. Combined group also exhibited increased in flexion peak torque and flexion and extension average power of knee. At the same time, exercise group without supplementation showed significant improvement ($p < 0.05$) on the knee flexion and extension peak torque at 60°s^{-1}as well as flexion average power flexion and extension average power at 300°s^{-1}. A comparison between Chen et al. (2016) with this study showed that resistance training alone, combined resistance training with *Lignosus rhinocerotis* supplementation and JH group in present study increase lower limb muscular strength in term of peak torque and average power values in young males. These findings demonstrate that both combined group in Chen et al study and JH could give an impact on isokinetic muscular strength and power. In fact, the greater significant changes in isokinetic muscular strength and power can also be observed in resistance training group (Chen et al., 2016), but not in jumping alone group in the present study. Differences in the training type, equipment used, and training duration may have contributed to differences between the results. The training duration in Chen et al. (2016) was approximately one hour per session. While in this study, the countermovement jumping exercise duration was approximately 6 min per session. These factors may be the reason for the discrepancy between the results in Chen et al. (2016) and those in this study. Nevertheless, this study has potential to improve isokinetic muscular strength and power after TH ingestion and followed by countermovement jumping exercise.

Conclusion

In conclusion, the combination of countermovement jumping exercise and Tualang honey supplementation have great potential for formulation guidelines in planning exercise and nutritional promotion program. This combination could also improve jumping height, standing long jump and isokinetic muscular strength and power in young in active males, and can be recommended as an alternative ergogenic aid for enhancing muscular performance.

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