

Research Article

Effect of Iso-Caloric Sago and Soy Supplementations during 90 Minutes Steady-State Cycling on Subsequent 20-km Cycling Time Trial Performance in the Heat

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Received: 10 August 2021

Revised: 2 September 2021

Accepted: 20 September 2021

Abstract

Background: In Asian countries, like Malaysia, India, and Thailand, sago (SA) is frequently used as daily food. The use of local daily food as supplements over expensive drinks is cost-effective for athletes. Hence, SA (carbohydrate) could be recommended as affordable nutrition ingestion. The purpose of this study was to determine the effects of SA, Soy (SO) protein, Sago+Soy (SS) supplementation (combination of carbohydrate and protein), and placebo (PL) during moderate-intensity cycling on subsequent 20-km time trial performance.

Materials and Methods: The participants were 12 young male well-trained cyclists from Malaysia. They pedaled at 60% of VO_{2max} for 90 min followed by a 20-km time trial (TT) in the heat. At 20 min intervals during cycling at 60% VO_{2max} , participants consumed either SA, SO, SS, or a PL. The SA, SO, and SS feedings provided 7.5% SA, 7.5% SO, and 7.5% SA+1.5% SO respectively to drink iso-caloric beverages with an estimated energy level ~300 kcal. The average speed and cadence were also recorded during the TT.

Results: Time taken for TT for SA, SO, SS, and PL were 42.8 ± 1.8 min, 46.3 ± 2.6 min, 42.7 ± 2.3 min, and 43.2 ± 1.8 min respectively. The TT performance, speed, and cadence of the cyclists did not exhibit any significant differences among the three trials.

Conclusion: These data indicated that consumption of sago and soy, and iso-caloric SS (coingestion of sago and soy) during steady-state ride failed to improve the subsequent cycling performance in the heat.

Keywords:

Carbohydrate, Protein, Iso-Caloric, Sago, Soy, Cycling Time Trial, Heat

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1. Introduction

Evidences suggest that carbohydrate (CHO) is among the most important nutritional factors for endurance performance (1, 2). The CHO ingestion before and during endurance exercise undertaken in the heat has been established to improve performance (3, 4). The CHO supplementation during endurance exercise is an influencing factor as a source of energy for the central nervous system and contracting muscles, indicating a permissive role on the performance in the heat (5). The specific mechanisms that CHO ingestion improves performance or delays fatigue have not been totally clarified, but the support of plasma glucose concentration is probably the reason (6). Meanwhile, the CHO contents in the body are restricted, and these resources are considerably fewer than the amount of required calorie for prolonged exercise carried out by many endurance athletes. Therefore, it is expected that this challenge to be of more important concern for such activities in a hot and warm condition, as the utilization rates of muscle glycogen are enhanced in the heat (7, 8). However, there is a reduced rate during exercise in the glycogen utilization, but post-acclimatization glycogenolysis is still higher when compared with a cooler condition (9).

In the tropical countries of Southeast Asia, like Malaysia and India, sago is used as a local source of CHO that their starch is extracted to produce sago flours (10, 11). The use of local daily food as supplements over expensive drinks is cost-effective where advertised available CHO products are not easily available to athletes (12, 13). Sago is agro-based locally available CHO that is widely used to prepare local staple foods, biscuit or ingest sago together with corn, potato, and rice, and in the production of pasta (11).

Sago starch comprises 27% amylose, 73% amylopectin, and it holds a high glycemic index of about 88 indicating that the relative ranking of CHO in sago leads to higher blood glucose concentrations that elicit a high glycemic response in exercise (10, 12, 14, 15).

It has been shown that the addition of protein (PRO) to CHO ingestion may produce performance benefits over a CHO supplement alone (12, 16, 17). Soy is one of the commercially accessible local sources of complete PROs in a diet plan (18). Many athletes have consumed soy in their meals due to the evidence that soy may provide benefits (12, 18-20) as its PRO is a combination of some amino acids similar to branched-chain amino acids (BCAAs) that contain valine, leucine, and isoleucine (21). In the Sports Science Unit Laboratory, School of Medical Sciences at Universiti Sains Malaysia sago starch has been extensively studied as a CHO supplement in exercise (10, 12, 22-26). Previously, this laboratory was the first academic institution, to our knowledge to examine the use of sago and soy supplementations during exercise (12, 15, 24, 27).

However, the intake of sago and soy supplementations during endurance exercise in the heat has not been investigated. The present study follows the earlier studies to examine the effects of iso-caloric sago and soy supplementations on 20-km time trial cycling performance (TT) which is the first attempt in a hot and humid condition (15). It has previously been observed that the additional amount of PRO to a CHO ingestion improved endurance exercise (17, 28) in the heat (29).

Additionally, a study from our laboratory reported endurance capacity was improved when cyclists consumed sago+soy supplements compared with sago alone (12). In this study, the total energy of the ingestions was not matched and their protocol was conducted in a thermoneutral condition. This recommends that an important reason for the benefits of sago and soy supplement is the additional availability of calories in sago+soy drinks. However, comparisons of CHO and PRO ingestions versus CHO supplements are often done without using iso-caloric between the supplements. Consequently, it is plausible that the addition of soy to sago ingestions as iso-caloric supplementations may improve endurance exercise in the heat. Therefore, the purpose of the present study was to investigate the effects of three commercially available sago, soy, and sago+soy supplements, matched for total calories, during steady-state cycling at 60% of $VO_2\text{max}$ for 90 minutes (SSC) as compared to placebo (PL) on the subsequent TT in the heat ($\sim 31^\circ\text{C}$; 70% relative humidity (RH)).

2. Materials and Methods

Subjects

Sample size calculations: The sample size of the current study was calculated by using PS Power and Sample Size Calculation v.2.1.30 (30). The power of the study was set at 80% with 95% confidence interval while standard deviation (σ) observed was 1, and the difference in population means (δ) was set at 2, and calculated sample size was 15 participants including the drop-out rate of 20%.

Study design: In this randomized single-blind, placebo-controlled cross-over study 12 male young cyclists were recruited from the Kelantan State team. Table 1 indicates their characteristics in more detail. They were moderately trained, heat acclimatized local cyclists. Acclimatization in these participants was obtained through existing training in a tropical condition in the Kelantan. They pedaled in the road training almost 3 times per week for at least 2 years. Each participant was informed about the training protocol and the possible risks before giving informed written consent to sign. The study was approved by the Human Research Ethics Committee, School of Medical Sciences, Universiti Sains Malaysia, and the Iranian Registry of Clinical Trials on 2020-08-03 (IRCT20190906044711N1). This study was funded by e-ScienceFund of the Ministry of Science, Technology and Innovation Malaysia (MOSTI). The project number is USM/0000814 at Universiti Sains Malaysia.

Table 1: Physical characteristics and physiological capacities of the participants (N=12).

Variables	Mean±SD
Age (years)	19.0±5.6
Height (cm)	170.8±7.6
Body weight (kg)	60.1±11.2
Body fat (%)	16.6±4.4
Body mass index (kg.m ⁻²)	20.5±3.0
Maximal oxygen consumption (ml.kg ⁻¹ .min ⁻¹)	56.5±6.5
Maximum heart rate (beats.min ⁻¹)	201.0±5.6

Participants fulfilled two preliminary tests to determine the physical fitness and workload of the SSC (figure 1). Sub-maximal test was to investigate the linear relationship between oxygen intake and work rate. This test was 16 min of cycling with workloads of 50, 80, 110, and 140watts per four min (12, 15, 24). Maximal oxygen uptake (VO₂max) test was to determine the participants' VO₂max directly. This test was a progressive activity that the initial workload at 50W and it was increased at a rate of 16W every minute until exhaustion (24, 31). Both tests were performed on an electronically braked ergometer (Excalibur Sport, Lode, The Netherlands) (12, 15, 24). One week after the preliminary tests, the participants were required to perform a familiarization trial, which it was similar to the actual trials. Nevertheless, the supplementations were not ingested by them, and distilled water was given to them.

Four actual trials were administered to investigate the effects of sago, sago+soy, soy, and PL supplementations during endurance SSC on the subsequent TT in the heat (Fig. 1).

Corresponding to the research design, each participant performed the four actual trials on four different occasions with a minimum of 7 days apart and at a similar time at 8:00 am in the morning. No verbal encouragement was given during the TT. They were also instructed to avoid strenuous exercise 24 hours and any supplements 48 hours before the beginning of each trial.

Protocol for experimental trials: For all trials, the chamber conditions were set at (~31°C, 70% RH). Standing fan, in the same position and fan speed at all times, were available to the participants to simulate wind velocity. On each trial, the participant reported to the Laboratory after 10 to 12 hours of overnight fast. An hour prior to the actual trial, the following procedures were carried out (15). Subjects' nude body weight was determined by using an electronic body composition analyzer (Tanita, TBF-410, Japan). Following that, participants were given a standardized breakfast, two slices of white bread and 250 ml distilled water 30 min before running the test (Fig. 2). Then, participants were asked to go to the chamber and mount on the ergometer bike to be ready for the test.

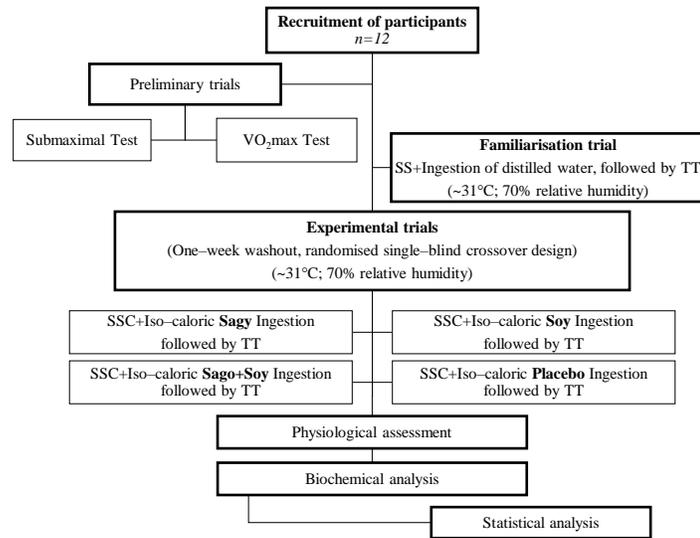


Figure 1. Experimental design of the study.
SSC= 90 min steady-state cycling at 60% of VO₂max,
TT = 20-km cycling time trial.

Immediately before warm-up, chamber temperature and RH were measured by using a whirling hygrometer (Brannan, England). The participants were asked to warm up for 5 min by cycling at 50% of their respective VO₂max, and the heart rate was measured using a heart rate monitor (S710, Polar, Finland). Chamber temperature and RH were recorded during the last minute of the warm-up. Then, the intensity of pedaling was increased to 60% of their respective VO₂max during the SSC, and the first supplementation was ingested at 0 min, then they kept pedaling for 90 min at that intensity, which was followed by the TT (15) (Fig. 2). At intervals of 15 min during the trial, heart rate, room temperature, and RH were recorded. Following the pedaling, participants drank the supplementation at 20 min intervals at 20, 40, 60, and 80 min of the SSC.

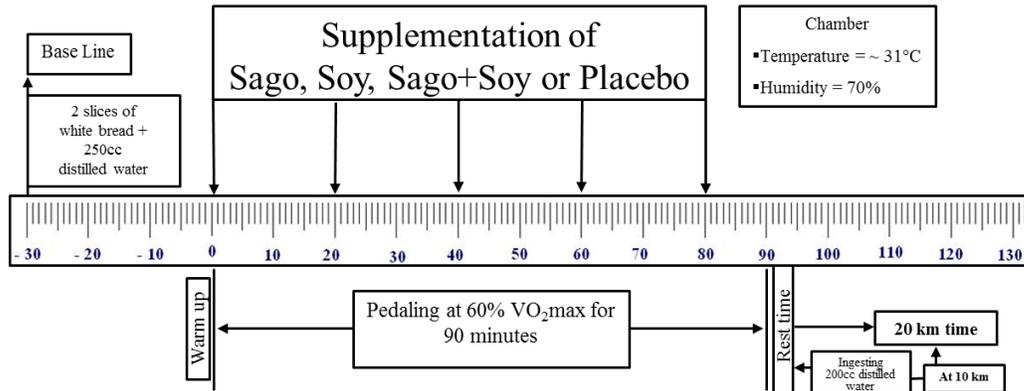


Figure 2. Protocol for experimental trials in the study.

Immediately after SSC participants were requested to rest in passive condition for 5 min in the chamber, and also to drink 200 ml distilled water. Then, at the last minute, they were asked to be ready to pedal for TT and mount on a bike (One Series Aluminium, Trek Road Bikes, USA). This bike was maintained by a trainer (CycleOps Power JetFluid Pro Trainer, USA) to create realistic accelerations, inertia conditions and offering real-world conditions for pedaling in the chamber. During the TT, the participants were free to control the speed of the cycling via a digital cyclometer (Cateye Strada Wireless, Japan), and at 10-km of the TT, 200 ml distilled water was given to them to drink during the pedaling.

Supplementations: Participants were requested to keep a record of their diet and activity plans on the day before the first trial and to perform again the same diet and physical activities 24 hours before the next trials. Sago and soy flours were chosen as the CHO and PRO supplementations in this research that were obtained from Sim Company Sdn. Bhd. Pinang (12, 15, 32, 33). Compositions of the four supplementations are shown in Table 2.

All supplementation meals and the PL had a similar specific taste of 5 ml of chocolate flavor in 1000 ml boiled water, with no calorie (Star Brand, Sdn. Bhd., Malaysia). The four types of supplementation were prepared according to the sago and soy flours on the same day before each trial and kept at room temperature (25°C) (24).

Table 2: The basic nutrient composition of the supplements

Supplement	Amount (mL)	CHO (g)	PRO (g)	Concentration (%)		Total energy (kcal)
				CHO	PRO	
Content per serving consumed during each experimental trial						
Sago	200	15	0	7.5	0	60
Soy	200	0	15	0	7.5	60
Sago + Soy	200	12	3	6.0	1.5	60
Placebo	200	0	0	0	0	0
Content of total consumed during each experimental trial						
Sago	1000	75	0	7.5	0	300
Soy	1000	0	75	0	7.5	300
Sago + Soy	1000	60	15	6.0	1.5	300
Placebo	1000	0	0	0	0	0

Ghosh, A. K., Rahaman, A. A. & Singh, R. (2010). Reference No. 17. Table 2. on page 217.

3. Results

All data were analyzed using the Statistical Package for Social Sciences (IBM SPSS Statistics v.26) for windows operation system. The normality of the data was determined by applying the Shapiro-Wilk test numerically, and the level of significance was set at $p < 0.05$. All the data were reported and stated in $M \pm SD$. The one-way analysis of variance (ANOVA) followed by LSD post-hoc was used to determine whether there were any significant differences between the means of duration of the TT, speed, and cadence as independent variables.

There were no significant differences in time trial performance among the four experimental trials ($p > 0.05$) (Fig. 3). The mean times to complete TT in four experimental trials of PL, sago, soy, and sago+soy were $42:46 \pm 04:08$ min, $43:00 \pm 04:08$ min, $46:13 \pm 05:37$ min, $43:34 \pm 04:22$ min respectively. Data pertaining to pedaling speeds and cadences are presented in Table 3. In the TT, the participants rode on a racing bike against the clock to secure the best performance during the four experimental trials with different speed and cadence.

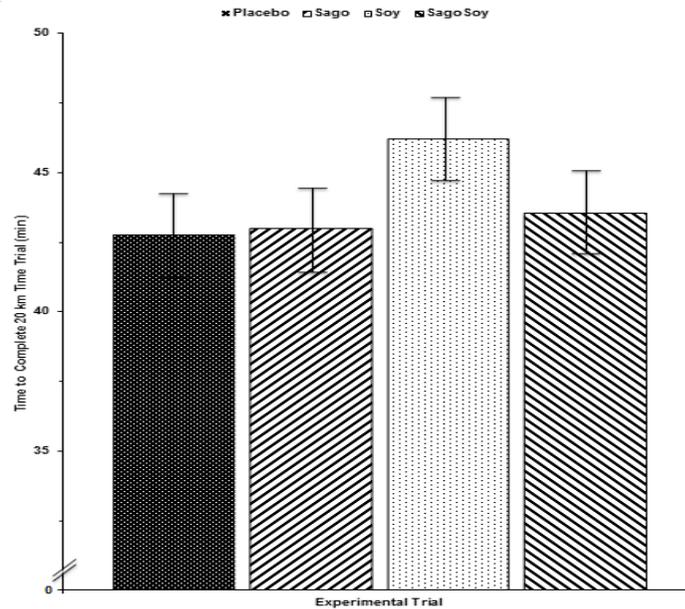


Figure 3. Time trial performance of the participants with ingestion of placebo, sago, soy, and sago+soy in the heat.

The average speeds in the four trials were not significantly different between experimental trials ($p>0.05$). In addition, there were no significant differences in the maximum speed between the trials ($p>0.05$), and the average pedaling cadence in the four trials were not significantly different ($p>0.05$). But, the soy trial was significantly different in maximum pedaling cadence from the other trials ($p<0.05$).

The results, as shown in Table 3, indicate that the participants pedaled soy trial with lesser average speed and cadence, but in the sago+soy trial, the maximum records were lesser when compared to the other trials ($p>0.05$).

Table 3: The speed and cadence records of the participants in 20-km cycling time trial in the heat (Mean±SD).

Trials	Speed (km.h ⁻¹)		Cadence (rpm)	
	Average	Maximum	Average	Maximum
Placebo	28.3±2.9	49.4±9.9	83.4±7.6	133.4±26.0
Sago	28.0±2.8	46.8±7.3	84.0±8.1	134.3±24.7
Soy	26.4±3.8	45.4±10.2	73.8±15.5*	126.0±20.0
Sago+Soy	27.5±2.6	44.±8.8	82.3±8.1	117.3±13.5

*Significantly different from the other trials ($p<0.05$).

4. Discussion

This is the first study to examine the effects of an iso-caloric coingestion of sago and soy on exercise in the heat (~31°C; 70% RH) (15). The main finding from the current study was that the ingestion of sago, soy, and sago+soy during SSC did not improve TT in the heat compared with PL. The results of the present study are not consistent with the other studies that have confirmed a beneficial consequence of CHO supplementation (34), sago ingestion (27), and sago+soy ingestions (24) during prolonged exercise. However, this finding is in agreement with some studies that have shown endurance performance did not improve with CHO supplementations (35-38). It was indicated in our previous published study that the sago and soy supplementations improved the plasma concentrations of glucose and insulin during the SSC (15). The iso-caloric CHO intake was 7.5% of sago flour, which contained 68.4% CHO based on the optimal amount of CHO ingestion during exercise (1).

During the endurance performance, the major energy source is CHO, and PRO provides a smaller role to produce energy (39). Thus, some studies have shown that CHO ingestion was able to improve performance. Carter et al. (2004) studied the CHO intake during cycling time trial at 63% VO_2max . Cyclists consumed either 6.4% CHO ingestion or a PL at the start and during cycling (34). The cycling performance was significantly shorter when the cyclists consumed CHO supplements. Recently, Learsy et al. (2019) also observed a similar result when cyclists completed 105 min of constant-load exercise, followed by a 10-km cycling time trial (2). They examined the CHO feedings of 2 ml.kg⁻¹ bodyweight of a supplement containing either 8% CHO or PL.

However, some studies did not observe any significant improvement in performance after CHO ingestions. Desbrow et al. (2004) did not detect any significant differences between 1-hour time trial for well-trained cyclists who ingested either 6% CHO supplements or a PL (35). They have also declared that the blood glucose availability was not significantly different by the CHO feeding in the time trials. Nassif et al. (2008) examined the effect of CHO intake either as a capsule or drink on the time trial cycling in the heat (36). They showed that CHO intakes did not improve the time trial in the heat. The CHO availability such as muscle glycogen was one of the main factors in exercise as well as the depletion of the energy substrates to affect the endurance capacities (36). They established that the time trial performance did not improve with the ingestion of CHO in the heat among fed cyclists. The CHO intake might have a little or no function to improve performance once cyclists were given the opportunity to self-pace in long-duration exercise.

A recent study by Muhamad AS et al. (2020) 10 male runners ran at 75% maximum heart rate for 1-hour on a treadmill, followed by 15 min time trial performance, and they ingested either CHO feeding or a PL every 15min (40). It was concluded that there were no significant differences when runners consumed CHO or PL during exercise. Based on the current evidence, in endurance athletes, training bouts as long as a marathon are dependent completely on CHO feeding (41). The CHO ingestion during endurance exercise helps prevent the reduction in blood glucose and CHO oxidation. However, the CHO availability was an important issue for the performance impairment.

Hence, the possible explanation for this might be that they used the iso-caloric intakes, where the caloric ingestion was matched between the feedings at levels that were intended to equal or exceed exogenous CHO-oxidation levels.

Some studies have also observed significant improvements in endurance performance once PRO was added to CHO ingestion. Ghosh et al. (2010) revealed that a combination of 52.2g sago and 15g soy could improve the time-to-exhaustion in a thermoneutral condition when compared with sago alone (12). In their study, participants ingested the sago+soy and sago drinks with 270 and 240 kcal respectively. Cathcart et al. (2011) concluded that CHO+PRO ingestion, as opposed to CHO alone, improved endurance exercise in the heat (29). In addition, the results of the other studies showed a performance improvement when a CHO+PRO drink was ingested compared with a CHO drink. However, they used different supplements in their work that were not iso-caloric because a CHO+PRO ingestions delivered further calories than a CHO supplement. For example, some investigators used a CHO+PRO ingestion that contained more calories than was used in the CHO ingestion (17, 28). Thus, the additional calorie content rather than PRO alone is responsible for the benefits of CHO+PRO ingestions during prolonged activity. Niles et al. (2001) were the first to show a positive result of an iso-caloric CHO+PRO supplementations compared with CHO alone on subsequent running time-to-exhaustion (42). Romano-Ely et al. (2006) investigated the impact of the caloric content of CHO+PRO or iso-caloric CHO on time-to-exhaustion cycling at 70% of VO_{2max} (43).

They established that the performance was similar once the supplementations consumed were iso-caloric.

Upshaw et al. (2016) used an iso-caloric CHO+PRO and CHO ingestions to explore their effects on subsequent time trial (44). They concluded that CHO+PRO improved the time trial when cyclists ingested CHO. In another study, Toone and Betts (2010) reported a negative effect of CHO+PRO ingestion where the mean cycling time trial was significantly slower by 0.94 % as compared to iso-caloric CHO consumption. In the present study, the intake of sago, soy, and combined iso-caloric sago+soy supplementation did not improve the TT performance in the heat despite the availability of the greater glycemic and insulinemic responses (15). Thus, CHO alone or a combined CHO+PRO supplementation may not be beneficial in exercise performance in the heat. While the results of this study differed from other published works (12, 17, 28, 45), it is consistent with those studies that have not shown any improvement after ingesting CHO+PRO supplements (46-48) in the heat (49-51). In conclusion, in this study, the endurance exercise (52), environmental conditions (53, 54), and CHO availability (55, 56) have been considered key modifiers of metabolic adaptation to support more calories during TT. Thus, these results add to the rapidly expanding field of supplementations for endurance exercise in the heat that sago and soy ingestions may not provide more calories when they are consumed during SSC despite the availability of the greater glycemic and insulinemic responses (15).

5. Conclusion

In conclusion, the present study was designed to determine the effects of sago, soy, and combined iso-caloric sago+soy supplementations during a SSC on TT in the heat. The present study is the first attempt in the heat, which follows the previous studies in the laboratory of the Sports Science Unit that studied the effects of sago and soy supplementations during exercise in a thermoneutral environment. This study has demonstrated that sago, soy, and iso-caloric sago+soy ingestions did not improve endurance performance in the heat when compared to PL drink. However, additional work is required to determine whether commercially available local sources of CHO and PRO similar to sago and soy would improve endurance exercise in the heat. Finally, this field of work is in progress, but current knowledge is still extremely narrow to find out more about the timing, amount of CHO and PRO supplementations during exercise.

Acknowledgements

We would like to thank University Sains Malaysia for the grant (305/PPSP/6113501) used to support this study. We wish to acknowledge laboratory staff from the Sports Science Unit, School of Medical Sciences, Health Campus, Universiti Sains Malaysia, Malaysia for their assistance in this study. Last but not least, our gratitude to all cyclists who were involved in this study. Daniel Tarmast (Ph.D.) graduated from Sports Science Unit in 2016 under the supervision of Prof. Asok Kumar Ghosh and Prof. Chen Chee Keong.

Funding

The study was approved by the e-Science Fund of the Ministry of Science, Technology and Innovation Malaysia (MOSTI) under the project number 'USM/0000814' at Sports Science Unit, Health Campus, University Sains Malaysia.

Compliance with ethical standards

Conflict of interest None declared.

Ethical approval The Ethics Committee of University Sains Malaysia approved the study. With code IRCT20190906044711N1.

Informed consent Informed consent was obtained from all participants.

Author contributions

Conceptualization: D.T., A.K.GH., CH.K.CH.;
Methodology: D.T., A.K.GH., CH.K.CH.; Software: D.T., A.K.GH.;
Validation: A.K.GH., CH.K.CH.; Formal analysis: D.T., A.K.GH., CH.K.CH.; Investigation: D.T., A.K.GH., CH.K.CH.;
Resources: D.T., A.K.GH., ; Data curation: D.T., A.K.GH.;
Writing - original draft: D.T., A.K.GH., CH.K.CH.;
Writing - review & editing: D.T., A.K.GH., CH.K.CH.;
Visualization: D.T., A.K.GH., CH.K.CH.;
Supervision: D.T., A.K.GH., CH.K.CH.;
Project administration: D.T., A.K.GH., CH.K.CH.;
Funding acquisition: D.T., A.K.GH.,

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