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Research Article / Araştırma Makalesi

Effect of low-dose acute ribose supplementation prior to and during repeated sprint exercise on anaerobic performance and blood lactate level

Tekrarlı sprint egzersiz öncesi ve sırasında düşük doz akut riboz takviyesinin anaerobik performans ve kan laktat seviye üzerine etkisi

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ABSTRACT

Objective: This study aimed to investigate the possible positive effects of acute low-dose ribose supplementation prior to and during repeated sprint interval exercise on anaerobic performance, blood lactate (BLa) levels, and perceived exertion.

Materials and Methods: In a double-blind, randomized and crossover design, a total of 20 healthy males (mean [standard deviation]: age= 20.8 [0.8] yr, body weight= 79.9 [11.3] kg) ingested either a ribose supplementation or placebo prior to and during a Wingate test involving 4×30-s all-out cycling against a load representing 7.5% of participant's body mass, with a 4-min of recovery at low-intensity between each sprint. The supplementation consisted of 2.5 g of ribose or placebo ingested 4 min before the Wingate tests and immediately after the 1st, 2nd, and 3rd sprint, for a total of 10 g.

Results: Ribose supplementation significantly increased the peak power output (mean difference (Δ)=75.0 W; p=0.016; effect size (d)=0.59), and the mean power output of the second sprint (Δ=39.5 W; p=0.03; d=0.52), with no notable change in other sprint performances. Rating of perceived exertion significantly increased after the tests (p<0.001; partial eta squared (η_p^2)=0.83), with no difference among the conditions (p>0.05). There was a slight but significant decrease in resting BLa before the Wingate test with ribose supplementation (Δ=0.05 mmol/L; p=0.047; d=0.48). The Wingate tests significantly increased BLa across time for both groups (p<0.001), yet levels of BLa prior to, during, and following the Wingate tests were similar among groups (p>0.05).

Conclusion: These results show that acute ribose supplementation does not remarkably impact anaerobic performance during repeated sprint exercise.

Keywords: *Ergogenic aid, interval exercise, dietary supplements, anaerobic performance*

ÖZ

Amaç: Bu çalışmanın amacı, tekrarlı sprint öncesinde ve sırasında akut düşük doz riboz takviyesinin anaerobik performans, kan laktat ve algılanan zorluk derecesine üzerine olası olumlu etkisini belirlemektir.

Gereç ve Yöntemler: Çift kör, randomize ve çapraz geçişli olarak planlanan çalışma kapsamında, 20 sağlıklı erkek (ortalama [standart sapma]: yaş=20.8 [0.8] yıl, vücut ağırlığı=79.9 [11.3] kg) vücut kütlesinin %7.5'ini temsil eden bir yüke karşı 4×30 s'lik tam süratle bisiklet sürmeyi içeren bir Wingate testi öncesinde ve sırasında riboz takviyesi veya plasebo aldılar. Sprintler arasında 4 dk'lık düşük şiddetli egzersiz uygulandı. Takviye protokolü, Wingate testlerinden 4 dk önce ve 1., 2. ve 3. sprintten hemen sonra toplam 10 g olmak üzere 2.5 g riboz veya plasebo alımından oluştu.

Bulgular: Riboz takviyesi, ikinci sprintin tepe güç çıkışını (ortalama fark (Δ) = 75.0 W; p=0.016; etki büyüklüğü (d)=0.59) ve ortalama güç çıkışını (Δ=39.5 W; p=0.03; d=0.52) anlamlı düzeyde geliştirirken, diğer sprint performanslarında kayda değer bir değişiklik bulunmadı. Algılanan zorluk derecesi, testlerden sonra gruplar arasında fark olmaksızın (p>0.05), Wingate testleri sırasında anlamlı ölçüde arttı (p<0.001; kısmi eta kare (η_p^2)=0.83). Riboz takviyesi ile Wingate testinden önce dinlenik kan laktatında hafif ama anlamlı bir düşüş bulundu (Δ=0.05 mmol/L; p=0.047; d=0.48). Kan laktatı düzeyi Wingate testleri sırasında önemli önemli ölçüde arttı (p<0.001), ancak bu artış testler öncesinde, sırasında ve sonrasında gruplar arasında benzerdi (p>0.05).

Sonuç: Bu sonuçlar, akut riboz takviyesinin tekrarlanan sprint egzersizi sırasında performansı önemli ölçüde etkilemediğini göstermektedir.

Anahtar Sözcükler: *Ergojenik yardım, tekrarlı egzersiz, diyet takviyeleri, anaerobik performans*

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INTRODUCTION

Ribose is a naturally occurring pentose carbohydrate, an important component in both the synthesis of adenosine triphosphate (ATP) and nucleotide salvage pathways (1). Ribose is a supplement marketed as a potential nutritional ergogenic aid for athletes to enhance the recovery in ATP levels following stress (i.e., intensive exercise) (1-3). Research reveals that ribose supplementation is beneficial in enhancing the necessary levels of cellular ATP recovery, during and following intensive exercise, and is considered to be a way of maintaining and increasing the ability to resynthesize the total adenine nucleotide (TAN) pool prior to, during, and following exercise in healthy males (4-6). In this regard, ribose seems to be an important supplement with a significant role as building block for nucleotides, coenzymes, nicotinate adenine dinucleotide phosphate, and nucleic acids (7-9). These findings strengthen the potential role of ribose supplementation in enhancing the recovery of muscle ATP and subsequently physical performance.

Research investigating the effects of ribose supplementation on exercise performance reported mixed results (7-15), with some studies citing benefits of ribose supplementation at different doses on muscle cramping, de novo synthesis of purine nucleotides capacity, peak power output, and rate of adenine nucleotide resynthesis (12-15), and others not presenting any significant effects of ribose supplementation on anaerobic exercise performance or fatigue index (11,16). Additionally, some research that has investigated the ergogenic property of ribose supplementation during high-intensity exercise reported that ribose ingestion for 3-5 d while engaging in repeated bouts of high-intensity exercise like Wingate-based sprint tests did exert limited effect on performance over those participants who were taking a placebo (3,10,11). For example, an early study by Gross et al. suggested that 2 g of oral ribose administration every 5 min during a 30-min submaximal cycling exercise led to higher blood lactate (BLa) concentration in young males, as well as blunted increases in plasma hypoxanthine in healthy participants, suggesting lower decrease in TAN (17). However, given the ability of ribose to enhance recovery in ATP levels, it remains unknown at present whether or not acute low-dose ribose supplementation during recovery periods between brief repeated sprints would improve anaerobic performance. Also, considering the discrepancies in mentioned studies, exploring the potential ergogenic value of ribose supplementation remains a fruitful area for future research. The purpose of this study was to determine the effects of acute low-dose ribose supplementation ingested prior to and during a Wingate-based repeated sprint interval exercise on anaerobic performance, BLa levels, and perceived exertion in young, healthy males. We hypothesized that ribose supplementation would increase anaerobic exercise performance through, in part, enhancing the availability of ATP and/or maintaining the TAN pool to a greater degree during a repeated session of high-intensity sprint-type activity known to cause drastic reductions in maximal power output and changes in creatine phosphate concentration, TAN pool, and inosine-5'-monophosphate (IMP).

MATERIAL and METHODS

Participants

Twenty-six recreationally active (≥3 d/wk for five years) males took part in this research voluntarily, and eligible participants were included based on the following criteria: being non-smokers, aged between 18-25 years, having no previous cardiopulmonary disease clinical history, and no musculo-skeletal injuries in the four months before the onset of the trial. None of the participants were involved in any form of nutritional supplementation that could compromise the administration of ribose supplementation. Following explanation of the purposes and associated risks of the study, institutionally approved written consent was obtained from each participant.

Experimental approach to the problem

All participants visited the laboratory on three occasions. On the first visit, following body mass (Tanita TBF 401 A, Japan) and stature (Holtain Ltd., UK) measurements, participants performed a single session of the Wingate test to become familiar with the testing procedure a week before the start of the study. During the subsequent two visits, two series of repeated Wingate tests were conducted with either ribose or placebo (PLC) ingestion administered in a randomized, double-blind, and cross-over design, with both conditions being separated by a 7-day washout period. Each participant was instructed to refrain from caffeine and alcohol for 24 hours and not to engage in any strenuous exercise 48 hours before each test, and to maintain their diet routine 24 h prior to two Wingate tests that were performed at the same time of day (09:00 a.m. - 12:00 noon).

Procedures

The study protocol is illustrated in Fig. 1. Participants reported to the laboratory following 3 h of fasting and consumed a 318 kcal standard meal composed of 54% CHO, 29% fat, and 17% protein one hour prior to the tests. In each test, participants performed a 4×30 s all-out effort against an external resistance corresponding to 7.5% of each participant's body mass on a bicycle ergometer (Monark 894E, Peak Bike, Sweden), following a standardized warm-up that involved 4 min of cycling on a cycle ergometer at an in-

tensity of 60 W. Verbal encouragement was applied for each participant during each all-out sprint effort. The 4 min recovery period between each all-out effort was performed against 1 kg of resistance at 60 rpm. Rating of perceived exertion (RPE) was measured with a $Borg_{6-20}$ (18) scale ranged between a low 6 (nothing at all) to a maximal of 20. The RPE scale was represented graphically on a paper so that participants could mark the number corresponding to their perceived exertion after each sprint.

Four minutes before the tests and immediately after the 1st, 2nd, and 3rd sprint, participants ingested either 2.5 g of ribose supplementation (Hardline Nutrition, Lonza, Switzerland) dissolved in 50 ml of water, or the same amount of dextrose (Fantomalt, Nutricia, UK) for a total amount of 10 g ribose or PLC. The tests were separated by a 7-day washout period. Capillary blood samples were collected from participants' fingertips (15-50µl) before the tests to benchmark resting BLa levels, and once again after each sprint (Lactate Scout, EKF Diagnostics, Germany). In addition, blood samples were taken immediately after and at the 3rd, 5th, and 7th min after the Wingate tests. The highest BLa level measured after the test was marked as the peak BLa level.

Statistical Analyses

Sample size was calculated based on repeated measures with ANOVA within factors using the G-Power statistics software (G*Power, v3.1.9.2, Franz Faul, Universitat Kiel, Dusseldorf, Germany), which revealed that the minimum sample size was 18, with an α error probability of 0.05, a research power of 0.95%, and an effect size of 0.25 (19). We calculated effect sizes (d) for paired data (pre vs. post) based on mean differences and the standard deviation (SD) of these differences (20). Paired sample t-test was used to compare the resting and peak BLa data levels between the conditions. For the variables measured several times in each trial (BLa, peak power, mean power, RPE), differences between ribose and PLC trials were identified with repeated-measures analysis of variance (ANOVA). Partial eta squared (n_p^2) was used to calculate effect sizes where required, and the effect size magnitudes were classified according to the Hopkins' scale: 0.0-0.2: trivial, 0.2-0.6: small, 0.6-1.2: moderate, 1.2-2.0: large, >2.0: very large (21). Data is presented as mean ± SD, as well as mean difference (Δ) and 95% confidence interval (95% CI). Statistical analyses were computed using SPSS Statistics for Windows, Version 21.0 (IBM Corp., Armonk, NY, USA), and the level of significance was set at $p<0.05$.

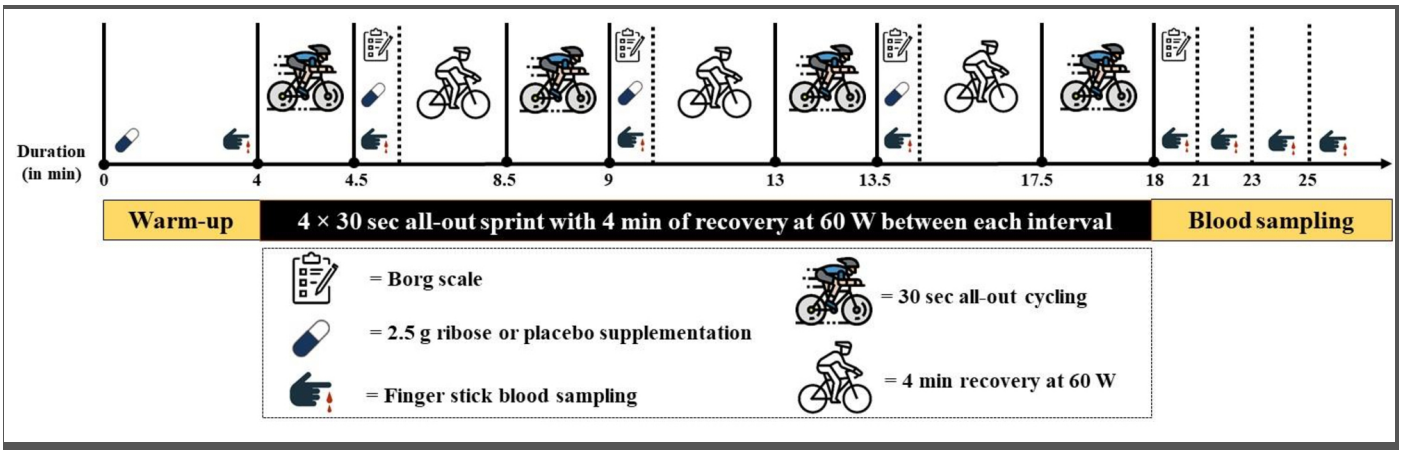

Figure 1. Experimental protocol

RESULTS

Twenty-six young, healthy males enrolled in this study, with six participants dropping out after completing the first visit due to personal reasons, resulting in a total of 20 participants that completed the tasks in the study without any adverse events, and henceforth, were included in data analysis. The baseline characteristics of participants are presented in Table 1.

Table 1. Baseline characteristics of participants

Variable	Mean	SD
Age, yr	20.8	0.8
Body weight, kg	79.9	11.3
Body stature, cm	180.4	9.7
BMI, kg/m²	24.6	3.6

BMI: body mass index; SD: standard deviation; n=20

Changes in performance parameters and rating of perceived exertion

Compared to PLC, ribose supplementation significantly increased the peak power output of the second sprint (Δ=75.0 W [95% CI 15.6 to 134.4]; p=0.016; d=0.59), with a trend to be statistically higher for the fourth sprint (Δ=29.0 W [95% CI -0.14 to 58.1]; p=0.051; d=0.47) (Fig. 2A). The mean power output of the second sprint was significantly improved with ribose supplementation compared with PLC (Δ=39.5 W [95% CI 3.8 to 75.1]; p=0.03; d=0.52) (Fig. 2B). There was no significant difference between ribose and PLC supplementation in the 1st, 3rd or 4th sprint performances (p>0.05, Fig. 2A-B). RPE significantly increased (p<0.001; η_p^2=0.83) after the Wingate tests, with no difference between groups (p>0.05; Fig. 2C).

Changes in blood lactate

There was a slight but significant decrease in resting BLa before the Wingate test with ribose supplementation (Δ=0.05 mmol·L^{-1} [95% CI 0.00 to 0.10]; p=0.047; d=0.48) (Fig. 3). Wingate tests significantly increased BLa across sprints for both groups (p<0.001), yet BLa levels were similar among groups before, during, and after the Wingate tests (p>0.05; Fig. 3).

DISCUSSION

This study has investigated whether acute ribose supplementation prior to and during sprint exercise would improve anaerobic capacity, BLa and perceived exertion during a Wingate-based sprint exercise in young, healthy males. Results indicate that a total of 10 g of acute ribose supplementation before and during repeated sprint exercise does not lead to a significant improvement in anaerobic performance, BLa, or RPE in young, healthy individuals, with limited effects on mean and power power output.

The breakdown of creatine phosphate after vigorous and short-term physical activity is the primary step for the AMP formed that is converted to inosine and hypoxanthine, suggesting the reduced muscle adenine nucleotide pool in equines (22-24). Current evidence indicates that increased cellular demand for ATP due to repeated, intense skeletal muscle contractions causes reduced TAN, which is responsible for energy production in the cell, while ribose can naturally increase the recovery of myocardial or skeletal muscle ATP and TAN levels following high-intensity exercise that in turn improves exercise performance. Due to the potential role of ribose in enhancing exercise performance, there has been growing interest in this area of research. Research reports that consuming 20 g/day of ribose for three days before high-intensity exercise resulted in significantly higher TAN levels measured immediately after a single session of high-intensity exercise, compared with PLC supplementation (25). Similarly, increased in vitro ribose availability after exercise was reported to lead to a 3.4-4.3-fold increase in de novo adenine nucleotide synthesis rates (26).

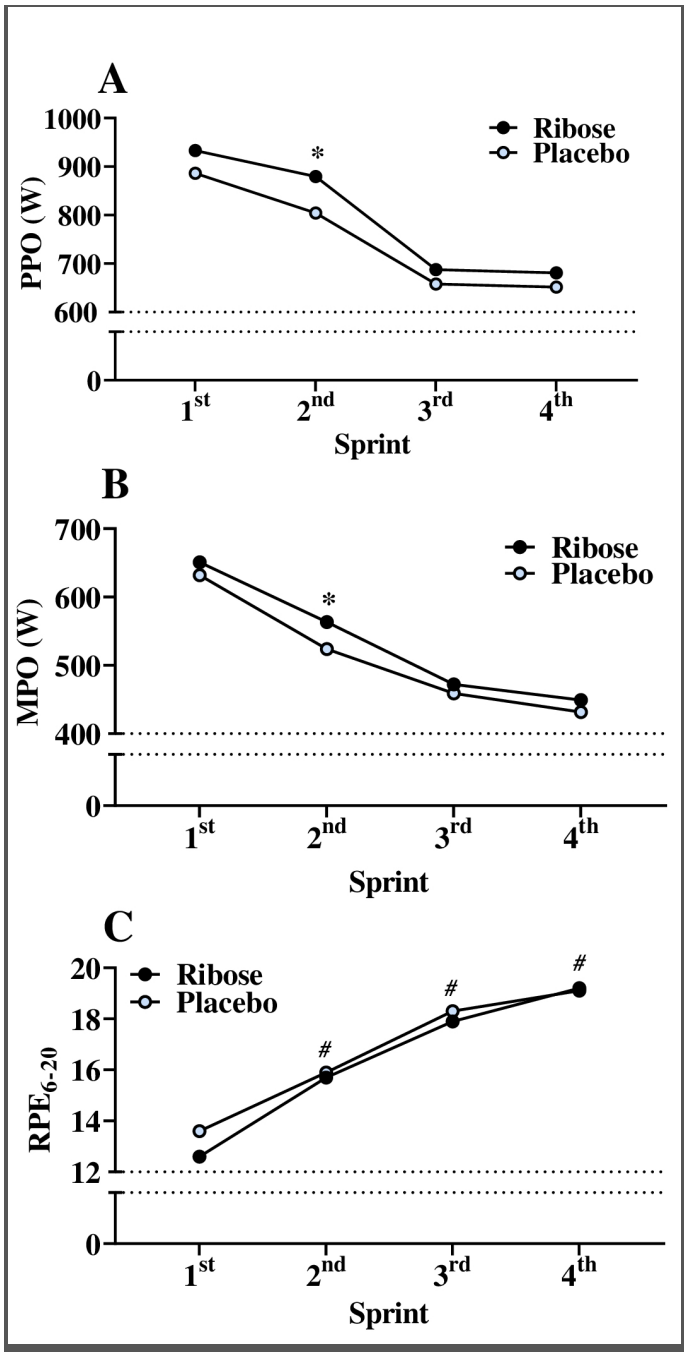

Figure 2. Peak power output (PPO) (A), mean power output (MPO) (B) and rating of perceived exertion (RPE_{6-20}) (C) after each sprint; *: p<0.05; #: significant difference (p<0.05) across sprints for both conditions"

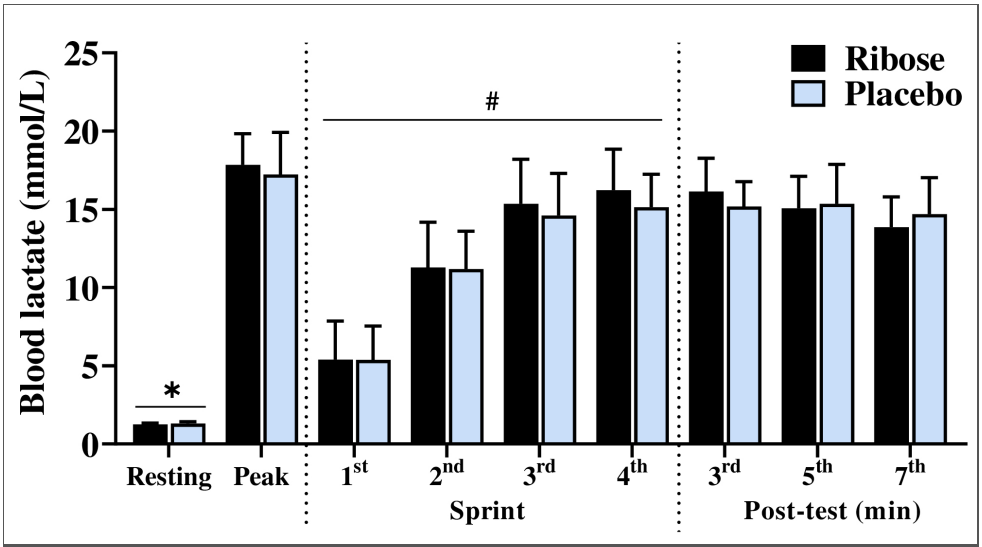

Figure 3. Change in blood lactate levels with placebo or ribose supplementation before, during, and after Wingate-based sprint test. *: p=0.047; #: significant (p<0.001) but similar (p>0.05) increase across sprints for both conditions

These findings suggest that ribose supplementation can increase the ability of the skeletal muscle to regenerate lost nucleotides, such as ATP, ADP, and AMP and can concomitantly improve exercise performance as reported with other supplements (27-30). However, in the present study, we found limited effects of acute ribose supplementation on exercise performance as evidenced by slight improvements in mean power and peak power during the Wingate test. It is likely that due to the lengthy process of de novo synthesis of adenine nucleotides, the low-dose ribose supplementation protocol applied in the present study failed to increase ATP resynthesis during the recovery period of a Wingate-based sprint test. Of the limited research, similar to our findings, most did fail to show the ergogenic benefits of ribose supplementation on exercise capacity in healthy untrained or trained populations (7, 25, 31). For example, Berardi et al. reported a significant increase in mean power (10.9%) and peak power (6.6%) in the 2nd sprint, with higher but no significant changes in the 1st, 3rd, and 4th sprints during a repeated cycle sprint exercise consisting of 6× 10-sec sprints with 60-sec of resting period between each sprint after 32 g of ribose or cellulose (4 × 8 g doses) 36 h before the exercise test in trained males (10). Although the findings of Berardi and associates were similar to those of the current study, the administration dose was lower in the present study (32 g versus 10 g), suggesting that participants' training status might play a role in mediating the impact of ribose supplementation on exercise performance. In support of this, Seifert and colleagues reported that 5 days (10 g/day) of ribose supplementation significantly increased mean and peak power output in individuals with low peak oxygen uptake (39.9 ± 4.1 mL/kg/min), but not in those with high peak oxygen uptake (52.2 ± 4.3 mL/kg/min) (9). Also, Kreider et al. reported that compared to a PLC supplementation, trained males who supplemented with ribose supplementation (10 g/d) for 5 days showed improved total work output measured with a 2 × 30 s Wingate cycle ergometer sprint, yet there was no significant change in metabolic responses or performance during repeated high-intensity exercise (11). Similarly, 3 g of acute ribose supplementation, 25 min before a repeated sprint test involving 3 × 30-s interspersed, with 3 min of passive recovery between each sprint, did not increase anaerobic performance or metabolic markers in moderately trained male cyclists (3). Also, Wagner et al. reported that 3 g of either placebo or ribose every 10 min started 1 h prior to an incremental maximal exercise test did not change exercise performance in patients with AMP deaminase deficiency (32), which coincides with our findings. These widely reported non-significant effects of ribose supplementation ingested before exercise tests on exercise performance might be due to de novo synthesis of ATP that might require longer time and higher dose of ribose to replenish muscle ATP levels during high-intensity interval exercise (16, 25, 31). Therefore, it is plausible that acute low-dose administration of ribose supplementation in the present investigation did not exert a significant effect on anaerobic performance during sprint interval exercise due to the limited time not allowing to reap ribose's full benefits. Further studies that have the participants ingest higher doses of ribose than administered in the current study and that provide long enough time before exercise tests would be welcomed.

In the current study, we also found that acute ribose supplementation did not alter levels of BLa. The previous findings on the effects of ribose supplementation on BLa are discrepant, with some research reporting increased BLa levels after ribose supplementation (2, 17, 32) and others not reporting any significant effects (3, 11). The beneficial effects of ribose supplementation on the increased plasma BLa concentrations during exercise may be due to an additional energy source (14). However, this hypothesis needs further investigation to draw a firm conclusion on the effects of ribose on BLa and energy metabolism.

The present study was subject to a number of potential methodological weaknesses. For example, the inclusion of a relatively homogeneous group consisting of recreationally active males is a limitation of this study. Further studies should assess whether there would be a sex-specific difference between males and females in exercise performance parameters following ribose supplementation. Also, the administration of ribose at different frequencies and doses should be investigated in recreationally active individuals who are likely to benefit more in order to ascertain whether ribose supplementation can operate as an ergogenic aid in healthy individuals.

CONCLUSION

Within the framework of this study, a total of 10 g acute ribose supplementation prior to and during a Wingate-based sprint interval exercise seems to exert a limited effect on anaerobic performance and metabolic responses to repetitive all-out exercise in young, healthy males.

Ethics Committee Approval / Etik Komite Onayı

The approval for this study was obtained from İstanbul Medipol University, GETAT Clinical Research Ethics Committee, Istanbul, Türkiye (Decision no: 11 Date: 16.06.2022).

Conflict of Interest / Çıkar Çatışması

The authors declared no conflicts of interest with respect to authorship and/or publication of the article.

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Author Contributions / Yazar Katkıları

Concept – HH,MMA,MK; Design - HH,MMA; Supervision – MMA; Materials – HH,MK; Data Collection and/or Processing – HH,MK; Analysis and Interpretation – HH,MMA,DK; Literature Review – HH,MMA,MK; Writing Manuscript - HH,MMA,DK; Critical Reviews - HH,MMA,FÖ,FK

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