BALTIC JOURNAL OF SPORT & HEALTH SCIENCES
No. 3(118); 2020; 4–12; ISSN 2351-6496 / eISSN 2538-8347
DOI: 10.33607/bjshs.v3i118.969

# Heart Rate Reactivity to Mental Stress in Athlete and Non-Athlete Children

**Krisztina Ábel, Attila Rausz Szabó, Attila Szabo**
*ELTE Eötvös Loránd University, Budapest, Hungary*

## ABSTRACT

*Background*. Research suggests that exercise training and/or physical fitness may be associated with lower heart rate reactivity and faster recovery from psychosocial stress. This relationship was rarely studied in children despite the potential protective role of physical activity in stress that may start in early life stages.

*Methods.* In this laboratory investigation we examined 18 athlete and non-athlete children before, during and following exposure to mental stress which consisted of the Stroop Color Word Task and a mental arithmetic task, both distracted by classical music, in a counterbalanced research design.

*Results.* The results based on absolute heart rate measures suggested that athletes exhibited lower heart rates in the stress-anticipation period as well as during the stress period than non-athletes. However, based on relative measures these differences vanished. The two groups of children did not differ in perceived arousal, perceived stressfulness of the mental tasks, and the self-reported feeling states before and after stress. Further, they did not differ in their performance on the two stress-eliciting active-coping tasks as indicated by the number of correct answers.

*Conclusion.* These results appear to suggest that athletic status in children is unrelated to heart rate reactivity and other subjective psychological experiences before, during and after acute psychosocial stress.

**Keywords:** adolescent, exercise, fitness, physical activity, relative measures.

## INTRODUCTION

The world's largest epidemiological study, the Global Burden of Disease Study (GBD), found that cardiovascular diseases (CVD) are the leading cause of death worldwide (GBD 2016 Causes of Death Collaborators, 2017). Early studies suggest that physiological response (reactivity) to mental stress might be a consistent predictor of the development of CVD in adults (Krantz & Manuck, 1984) as well as in children (Parker et al., 1987). Elevated heart rate reactivity (HRR) to mental stress was associated with increased neuroendocrine response (Lovallo, Pincomb, Brackett, & Wilson, 1990), atherosclerosis (Sharpley, 2002), hostility (Larson & Langer, 1997), Type A behavior (Palmero, Luis Díez, & Breva Asensio, 2001), antisocial behavior (Crozier et al., 2008), increased immune response (Larson, Ader, & Moynihan, 2001) and low physical fitness (Forcier et al., 2006).

Cross-sectional studies examining high and low fit men exposed to a mental arithmetic (MA) task, which is one of the most common laboratory stressors (Seraganian, Szabo, & Brown, 1997), reported that fit men exhibited lower HRR to stress than their less fit counterparts (Czajkowski et al., 1990; McCubbin et al., 1992). Using a reaction time stressor instead of MA, these findings were also corroborated in high and low fit young men (van Doornen & de Geus, 1989). However, in a study using high and low difficulty MA, and testing both men and women, Szabo Brown, Gauvin, and Seraganian (1993) did not find a direct connection between aerobic fitness and HRR. Later, a meta-regression analysis also concluded that there was insufficient evidence for supporting the conjecture that cardiorespiratory fitness is generally related to the attenuation of stress reactivity (Jackson & Dishman, 2006).

Stress reactivity in children has received little attention despite the conjecture that the precursors of CVD occur in childhood (Murphy, Alpert, Willey, & Somes, 1988). Indeed, research evidence shows that cardiovascular reactivity to laboratory stress is a predictor of blood pressure in adolescents (Matthews, Salomon, Brady, & Allen, 2003; Matthews, Woodall, & Allen, 1993). It was also reported that reactivity to mental stress in children is associated with increased left ventricular mass, which in turn is connected to increased risk of CVD (Allen, Matthews, & Sherman, 1997). Further, central adiposity in children also appears to be related to greater stress reactivity (Roemmich, Smith, Epstein, & Lambiase, 2007). While reactivity to mental stress in children appears to be positively related to CVD, physical activity has a protective role (Andersen, Riddoch, Kriemler, & Hills, 2011). Therefore, it is not surprising that a few studies have also looked at the relationship between physical activity and stress reactivity in children.

In the context of cardiorespiratory fitness, it was reported that overall physical activity level was negatively related to the psychosocial stress response in children (Martikainen et al., 2013). However, opposite findings were disclosed in smaller scale research in which aerobic fitness was positively associated with stress-reactivity in children (Roemmich, Lambiase, Salvy, & Horvath, 2009). Further, in an earlier work by Ferrara et al. (1993), only a small difference was observed between physically active and sedentary children in cardiovascular reactivity to mental stress. Finally, the only study with athlete children (to the best of these authors' knowledge) revealed that aerobic fitness level ($VO_2$ Max) did not affect the HRR to mental arithmetic, but the aerobically more fit judo athletes recovered faster from psychosocial stress than their less fit counterparts (Szab**ó** et al., 1994). Therefore, similarly to research with adults, the link between physical activity, and/or level of fitness, and the reactivity to psychosocial stress is controversial in children too.

The objective of the present work was to examine whether athlete children have lower HRR to mental stress than their non-athlete counterparts and, therefore, whether early athletic status might be implicated in having a protective role on the precursors of CVD (Murphy et al., 1988). A similar question was raised nearly three decades ago in a cross-sectional study (Ferrara et al., 1993) but failed to disclose difference in HRR to mental arithmetic between children practicing sports and those being physically less active. However, these authors conceptualized physical activity as based on Saltin's questionnaire (Saltin & Grimby, 1968) that was aimed at measuring leisure time physical activity. In contrast, here we examined competing athletes and non-athletes who were interested in becoming athletes in the same sport, thus ascertaining a wider gap in athletic and/or physical activity status. To keep the intervention the least invasive, we simply monitored HRR which is only a crude, but nevertheless very sensitive, index of the cardiovascular response to stress (Péronnet & Szabo, 1993). Further, to complement the HRR measures with psychological data, we also assessed perceived feeling states and felt arousal before, during and after the stress exposure period. Finally, in contrast to Ferrara et al.'s (1993) study, we also looked to relative HRR in addition to absolute measures. Our hypothesis was that athletes would exhibit lower HRR response to and faster recovery from a short episode of psychosocial stress in contrast to non-athletes.

## METHOD

**Participants.** After receiving ethical clearance for the study from the Research Ethics Board of the Faculty of Education and Psychology of the ___________ University[1], children aged between 11–15 years ($M_{age}$ = 11.94, $SD$ = 1.06) were recruited, with the consent of their parents or guardians, in a large suburban canoeing club. Athletes training an average of 10.78 (SD = 3.70) hours per week for at least one year and newcomer children exercising 1.56 (SD = 2.46) hours per week were solicited to participate with the help of the Head Coach. A total of 18 children (nine athletes and nine non-athletes), comprised by 11 boys and seven girls, volunteered for the study. Apart from the weekly hours of exercise ($M = 10.78 \pm SD = 3.70$ vs. $M = 1.56 \pm SD = 2.45$), athletes and non-athletes did not differ in age, height and weight. All children were white and lived in the same suburban area. The study protocol followed the World Medical Association Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects (WMA, 2019). Given that it took a very long time to recruit children (due to the nature of the study [stress research] and dependence on the number of newcomers), we relied on the *a priori* sample size calculation using the G* Power (v. 3.1) software (Faul, Erdfelder, Buchner, & Lang, 2009) as based on four measures that were repeated in two groups with the following parameters: medium effect size ($f$) = .25, α = .05, $r$ = .65, and power (1 – $\boldsymbol{\beta}$) = .80.This estimate yielded a minimum required sample size of 18 and, therefore, after

[1] Name withheld for anonymity

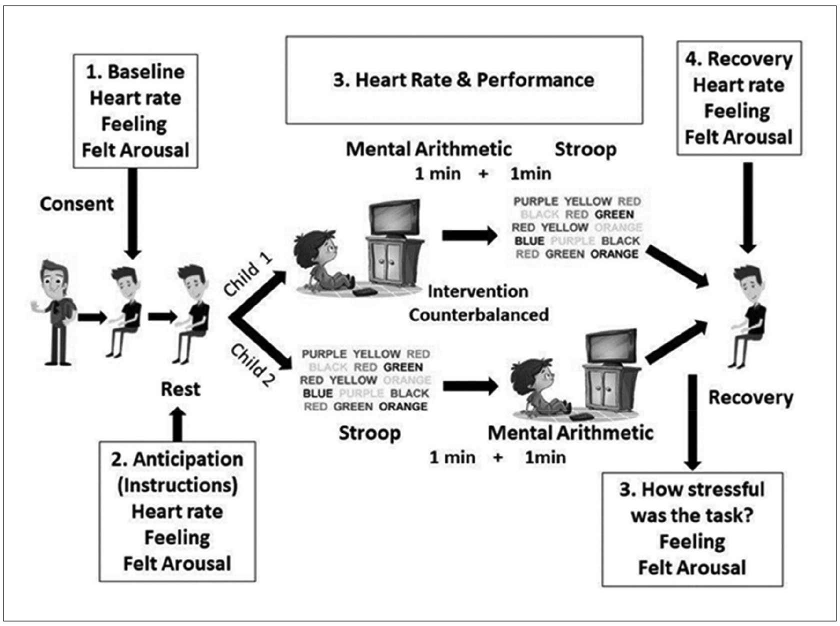
testing nine athletes and nine non-athletes no further recruitment was performed.

**Measures.** ***Stressors and Heart Rate.*** The Stroop Color Word Task (SCWT; Stroop, 1935), in which color words are presented in incongruent colors (i.e., the word 'blue' displayed in red), was used as one of the two mental stressors. Its stress-inducing potential was shown in several studies (Karthikeyan, Murugappan, & Yaacob, 2011). The task of the participant is to ignore the semantic content of the word and name aloud the color in which the serially displayed words appear on a laptop screen placed 1.0 m away from her/him. The other stressor was a mental arithmetic (MA), which is a validated intervention in stress research (Ein, Hadad, Reed, & Vickers, 2019). In the current study it consisted of serial verbal subtractions by 13 from a number between 901 and 999 as fast and as accurately as possible. The starting number was randomly generated on a Lenovo laptop's screen. To increase the impact of the stressors, classical music (Beethoven's Symphony no. 7 in A major op.92. from Szabo, Small, & Leigh, 1999) was played in the background at 80 dB throughout the two-minute stress period. Heart rate was monitored with a Polar OH1 optical heart rate sensor (Model 2L, Serial number: 92070523) placed on the left forearm. The measurements were stored in the internal memory of the device. Research indicates that Polar monitors provide valid measures of HR during mental stress (Goodie, Larkin, & Schauss, 2000).

***Paper and Pencil Measures.*** The Feeling Scale (FS; Hardy & Rejeski, 1989) was used to determine how children feel about their participation at the various stages of the experiment. Similarly, the Felt Arousal Scale (FAS; Svebak & Murgatroyd, 1985) was used to measure the subjectively perceived level of arousal at the start and at various phases of the experiment. The former scale gauges affective valence on an 11-point Likert scale ranging from –5 (feeling very bad) to +5 (feeling very good), while the later measures activation on a 6-point Likert scale ranging from 1 (low arousal) to 6 (high arousal). The perceived stressfulness of the SCWT and MA was measured on an 11-point Likert scale ranging from 0 to 10.

**Procedure.** After agreeing to participation, children were scheduled for the day of the experiment. Upon arrival to the laboratory they signed a consent form and entered test Phase 1, named *baseline*, in which they rested for three minutes. This phase was followed by the first HR measurement, feeling state and felt arousal. Next, in Phase 2, named as *anticipation* period, the experimenter provided instructions for the SCWT and MA and before the start of the two tasks HR, feeling state and felt arousal were reassessed. Subsequently, in Phase 3, named as *stress* period, the two stressors were presented in counterbalanced order to the participants. For example, the odd number participant performed the MA first and then the SCWT, while the even number child performed the tasks in the reverse order for one-minute each. During the two-minute stress period HR and performance on both tasks was recorded. Immediately after the stress period children rated the perceived stressfulness of the tasks the average of which was taken as an index of the perceived stress level. At the same time, participants rated their feeling state and felt arousal. Finally, in Phase

Figure 1. **Illustration of the experimental protocol**



4, named as *recovery* period, after three-minutes of rest, participants' HR, feeling state and felt arousal were recorded for a last time. The experimental protocol is visually summarized in Figure 1.

## RESULTS

Since the Kolmogorov-Smirnov and Shapiro-Wilk tests indicated that the assumption of normal distribution was violated in more than half of the dependent measures we employed non-parametric tests for data analyses. It was suggested that these tests are the most useful for smaller studies (Fagerland, 2012) and, in contrast to the models on which parametric tests are based, they are less restrictive and permit more general inferences, even though they are less powerful (Siegel, 1957).

Given that both boys and girls participated in the current study, we first compared the two genders on all dependent measures using the Mann-Whitney *U* test. These tests revealed that boys and girls only differed in three measures including baseline arousal (Mean ranks = 12.00 and 5.57, respectively, $Z = -2.75$, $p = .006$, effect size [$r$] = .65), arousal after stress (Mean ranks = 11.73 and 6.00, respectively, $Z = -2.30$, $p = .022$, $r = .54$), and performance on the SCWT (Mean ranks = 7.09 and 13.29, respectively, $Z = -2.42$, $p = .016$, $r = .57$). On arousal measures the girls had lower scores whereas on SCWT performance they had higher scores than boys.

The Mann–Whitney *U* test was also employed to compare athletes and non-athletes on the dependent measures. Statistically significant differences only emerged in the absolute HRs during the anticipation and stress periods, while a trend was observed in baseline as well as recovery HR (Table). The HR results indicated that athletes' HR was consistently

Table. **Summary of Mann–Whitney *U* tests comparing athlete and non-athlete children**

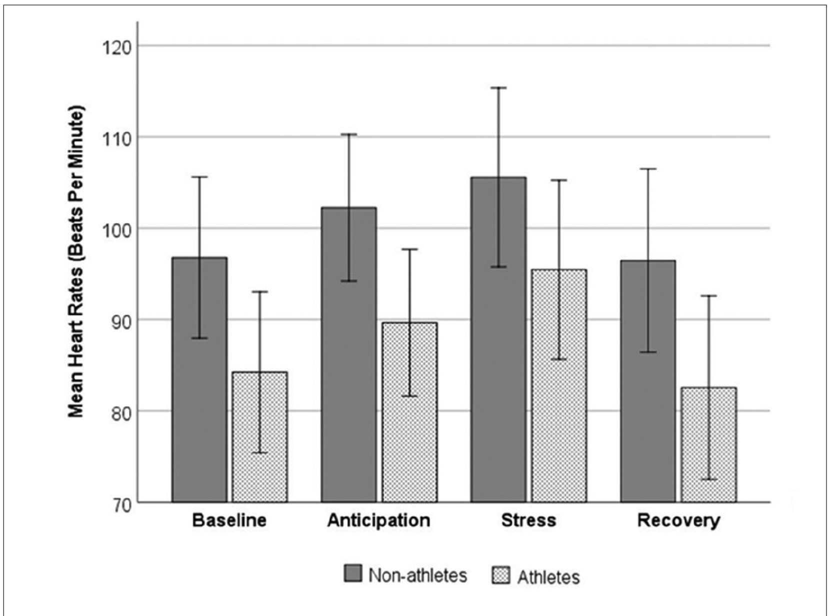
| Measures | Groups (n = 18, 9 / group) | Mean Rank | *Z* | *p* | Effect size (*r*) |
|---|---|---|---|---|---|
| Weekly hours of exercise | Athlete<br>Non-athlete | 13.78<br>5.22 | –3.44 | < .001 | .811 |
| Baseline HR | Athlete<br>Non-athlete | 7.17<br>11.83 | –1.86 | .063* NS | .431 |
| Anticipation HR | Athlete<br>Non-athlete | 6.39<br>12.61 | –2.48 | .013 | .585 |
| Stress HR | Athlete<br>Non-athlete | 6.67<br>12.33 | –2.25 | .024 | .530 |
| Recovery HR | Athlete<br>Non-athlete | 7.11<br>11.89 | –1.90 | .057* NS | .448 |
| Arousal baseline | Athlete<br>Non-athlete | 9.33<br>9.67 | – 0.15 | .884 NS | .035 |
| Arousal anticipation, before stress | Athlete<br>Non-athlete | 8.89<br>10.11 | –0.51 | .611 NS | .120 |
| Arousal after stress | Athlete<br>Non-athlete | 10.22<br>8.78 | –0.60 | .552 NS | .141 |
| Arousal during recovery | Athlete<br>Non-athlete | 9.22<br>9.78 | –0.23 | .820 NS | .054 |
| Feeling state baseline | Athlete<br>Non-athlete | 11.67<br>7.33 | –1.81 | .070 NS | .427 |
| Feeling state anticipation, before stress | Athlete<br>Non-athlete | 10.78<br>8.22 | –1.05 | .292 NS | .247 |
| Feeling after stress | Athlete<br>Non-athlete | 10.61<br>8.39 | –0.90 | .366 NS | .212 |
| Feeling state during recovery | Athlete<br>Non-athlete | 9.72<br>9.28 | –0.19 | .852 NS | .045 |
| Stressfulness of the tasks | Athlete<br>Non-athlete | 11.06<br>7.94 | –1.28 | .201 NS | .302 |
| Performance on SCWT | Athlete<br>Non-athlete | 10.17<br>8.83 | –0.53 | .594 NS | .125 |
| Performance on MA | Athlete<br>Non-athlete | 9.89<br>9.11 | –0.31 | .755 NS | .073 |

**Note**. * May be considered a trend; HR = Heart Rate; MA = Mental Arithmetic; NS = nonsignificant; SCWT = Stroop Color Word Task.

lower than that of non-athletes (Figure 2). The two groups did not differ in their feeling states or levels of arousal in any of the four phases of the laboratory experiment. Further, they did not differ statistically significantly in their performance either on the SCWT or MA, nor in their ratings of perceived stressfulness of the two-minute stress period.

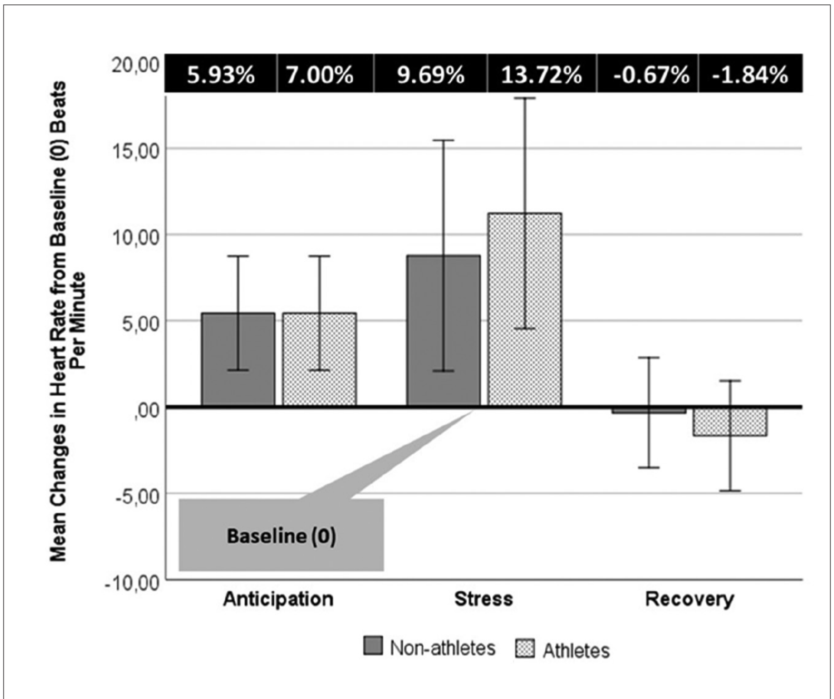
Further Mann–Whitney *U* tests were performed to compare athletes and non-athletes based on their relative HRs. These scores were calculated as raw difference (Delta [**Δ**]) scores by subtracting the baseline HR from anticipation, stress and recovery HRs. The mean change in HRR to stress was 10.00 beats per minute (bpm) ± *SD* = 9.26, with high inter-individual variability ranging between –6 and 29 bpm. Moreover, we also computed the percent relative Δ scores by calculating the percent change in HR in contrast to the baseline (see top of Figure 3). The mean percent HRR to stress was 11.71% bpm ± *SD* = 10.17%, showing again high inter-individual variability ranging between –5.04% and 27.88% bpm. The Mann-Whitney *U* tests were statistically not significant neither for the raw Δ scores nor for the percent Δ scores (Figure 3).

Figure 2. **Heart rates at baseline and in three phases of stress exposure**




**Note.** Error bars represent the 95% confidence intervals.

Figure 3. **Relative (to baseline) changes in heart rate in three phases of stress exposure**




**Notes.** Error bars represent the 95% confidence intervals. No statistically significant group differences were observed as based on Mann-Whitney *U* tests.

## DISCUSSION

The results of this laboratory investigation show that athlete and non-athlete children differ in their heart rate response to mental stress during and immediately after stress exposure if the absolute heart rate measures are considered. However, when the relative HRR is taken into consideration these differences vanish. Therefore, a lesson learned from this study it that it is important to account for the baseline or pre-stress values in studying the stress reactivity in children. Nevertheless, athletes showed an overall lower absolute HRR in all phases of mental stress compared to non-athletes. Despite this difference, in this study the athletic status could not be associated with a superior, or healthier, HRR to mental stress in children. Indeed, if we were not considering the relative HRRs, we could have had erroneously concluded that athlete children exhibited lower reactivity to stress than non-athlete children (refer to Figure2). Thus, despite negative findings, the present work provides empirical evidence that different results will emerge with the analysis of the absolute or raw values in contrast to relative values.

Our results partially agree with a meta-regression analysis showing that there is not enough evidence for the presumption that cardiorespiratory fitness is related to lower stress reactivity (Jackson & Dishman, 2006). While we did not measure the level of fitness of the participants, based on the weekly hours of exercise, which were almost seven times more in athletes than non-athletes, it can be presumed that athletes had higher levels of fitness than non-athletes. Considering the absolute HRR to psychosocial stress, our findings also agree with the results of Ferrara et al. (1993) but disagree with those if we consider the relative HRR that was not reported by those authors. Finally, our results partially also agree with the only study reported with athlete children (Szabó et al., 1994) that did not find difference in HRR during mental arithmetic between more and less fit judo athletes. Nevertheless, in that study higher and lower fitness levels were compared without the use of a non-athlete control group like in the current work. Further, in the present study aerobic fitness ($VO_2$ max) was not determined. Thus, a comparison between the two studies examining the HRR to psychosocial stress in young athletes cannot be made. From a methodological perspective, however, both studies relied on the relative heart rates of the children in the scrutiny of the group differences, which is a clear advantage over the study reported by Ferrara et al. (1993). Moreover, the current study used a sort of 'waiting-list comparison group' (Blumenthal et al., 1989), or perhaps more correctly a 'similar interest comparison group' comprised by participants who *wanted to* become athletes in the same sport as those athletes with whom they were compared. Therefore, these results are more comparable to Szabó et al.'s (1994) research who examined more and less fit judokas than to Ferrara et al. (1993) who contrasted physically active with sedentary, or less active, children, because the sedentary children might differ from the physically active group in measures for which the researchers may not be able to account (i.e., personality, motivation factors, self-esteem, self-identity, competence motivation, etc.). While interest in the same sport does not fully address the contamination of the results by extraneous variables, it provides a slightly more homogeneous basis for the comparison.

The present study also shows a non-significant tendency in greater relative HRR to psychosocial stress in athletes compared to non-athletes (refer to Figure 3), which might be significant with a larger sample size. While this conjecture is speculative, considering that athletes exhibited more than four percent (4%) greater relative HRR to psychosocial stress than non-athletes (refer to Figure 3) and that there was high inter-individual variability in the HRRs, statistically significant differences may emerge in larger samples. Such finding would agree with the report of Roemmich et al. (2009) disclosing higher HRR to stress in aerobically more fit children. Perhaps, this line of investigation merits further research attention, because greater reactivity in the more fit children may not necessarily reflect malfunction, but rather a better adapting cardiovascular system to psychosocial stress, especially if that is accompanied by faster recovery like in Szabó et al. (1994) study. In this study, based on visual examination of Figure 3, there was also tendency in greater recovery from stress in athletes compared to non-athletes, but again the low sample size along with the high inter-individual variability, could have masked the possible between-groups difference. Nevertheless, these tendencies might provide incentive for further research with larger samples and more statistical power.

The present investigation expands previous similar research because in addition to a physiological measure it also gauged the subjective feeling states, felt arousal, the perceived stressfulness of the two psychosocial stressors as well as performance on the cognitive tasks. Athletes and those to become athletes did not differ in any of these subjective measures as it can be seen in Table. However, girls exhibited lower perceived arousal at baseline and after the stress-episode than boys despite the lack of statistically significant differences in heart rate measures. These findings were also unrelated to the subjectively perceived stressfulness of the psychosocial stressors which did not differ between the two genders. There is little research on gender differences in perceived arousal in the context of emotional challenges, especially in children. A study with adults, however, revealed that women exhibited grater arousal in response to passive stress (no control possible) than men (Bianchin & Angrilli, 2012). It is possible that in response to active stress, such as the two tasks used in the current study, the two genders exhibit different levels of arousal. This line of investigation remains open in both adults and children.

**Strengths and Limitations.** A strength of the current study is that it examined HRR to two types of active psychosocial stressors in children athletes in a counterbalanced design, thereby adding to the very few studies examining this issue in children and to the only previous study (Szabó et al., 1994) looking at athlete children. The further strength of the work is that it provides evidence for different results obtained based on absolute and relative measures, which obviously give rise to different conclusions. Using relative measures in studying stress-reactivity in children is highly recommended as based on the current findings. Finally, another, possible strength of the current work is that in addition to a crude but sensitive physiological measure (Péronnet & Szabo, 1993) is also assessed subjective measures as well as performance measures on the tasks presented as stressors.

Despite the above strengths the study has several limitations. The most obvious one is the small sample size. However, it should be realized that it is very difficult to recruit children for stress-research and to obtain parental consent for such investigations. Larger scale studies in this context may need to be opportunistic, such as in-situ studying of psychophysiological responses to video games in video arcades or other active challenges in amusement parks. The laboratory testing of children in stress research remains difficult, which is illustrated by the limited number of earlier studies in this field. The other limitation of the study, again due to the low sample size, is that gender related interaction effects could not be investigated despite some gender differences in arousal and performance were observed. Finally, the current work also embeds the general problem of volunteerism in psychological research, but testing non-volunteers, especially children exposed to stress, is ethically unrealizable in this field.

## CONCLUSIONS

Athlete children show lower heart rate reactivity to psychosocial stress than non-athlete children, based on absolute measures. However, an opposite trend emerges if the relative heart rates are considered. Athlete and non-athlete children do not differ in the perceived stressfulness of laboratory challenges, felt arousal before and after mental stress, and feeling states before and after exposure mental stress. The take home message of this laboratory work is that it is very unlikely that athletic status plays a protective role against psychosocial stress in children and this finding is consistent with the few research results with children as well as with the results of studies that examined adult samples.

## REFERENCES

Allen, M. T., Matthews, K. A., & Sherman, F. S. (1997). Cardiovascular reactivity to stress and left ventricular mass in youth. *Hypertension, 30*(4), 782–787. https://doi.org/10.1161/01.hyp.30.4.782

Andersen, L. B., Riddoch, C., Kriemler, S., & Hills, A. (2011). Physical activity and cardiovascular risk factors in children. *British Journal of Sports Medicine, 45*(11), 871–876. https://doi.org/10.1136/bjsports-2011-090333

Bianchin, M., & Angrilli, A. (2012). Gender differences in emotional responses: A psychophysiological study. *Physiology & Behavior, 105*(4), 925–932. https://doi.org/10.1016/j.physbeh.2011.10.031

Blumenthal, J. A., Emery, C. F., Madden, D. J., George, L. K., Coleman, R. E., Riddle, M. W., … Williams, R. S. (1989). Cardiovascular and behavioral effects of aerobic exercise training in healthy older men and women. *Journal of Gerontology, 44*(5), M147–M157. https://doi.org/10.1093/geronj/44.5.m147

Crozier, J. C., Dodge, K. A., Fontaine, R. G., Lansford, J. E., Bates, J. E., Pettit, G. S., & Levenson, R. W. (2008).

Social information processing and cardiac predictors of adolescent antisocial behavior. *Journal of Abnormal Psychology, 117*(2), 253–267. https://doi.org/10.1037/0021-843x.117.2.253

Czajkowski, S. M., Hindelang, R. D., Dembroski, T. M., Mayerson, S. E., Parks, E. B., & Holland, J. C. (1990). Aerobic fitness, psychological characteristics, and cardiovascular reactivity to stress. *Health Psychology, 9*(6), 676–692. https://doi.org/10.1037/0278-6133.9.6.676

Ein, N., Hadad, M., Reed, M. J., & Vickers, K. (2019). Does viewing a picture of a pet during a mental arithmetic task lower stress levels? *Anthrozoös, 32*(4), 519–532. https://doi.org/10.1080/08927936.2019.1621524

Fagerland, M. W. (2012). T-tests, non-parametric tests, and large studies – a paradox of statistical practice? *BMC Medical Research Methodology, 12*(1). https://doi.org/10.1186/1471-2288-12-78

Falkner, B., Kushner, H., Onesti, G., & Angelakos, E. T. (1981). Cardiovascular characteristics in adolescents who develop essential hypertension. *Hypertension, 3*(5), 521–527. https://doi.org/10.1161/01.hyp.3.5.521

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 4*1(4), 1149–1160. https://doi.org/10.3758/brm.41.4.1149

Ferrara, L. A., Mainenti, G., Fasano, M. L., Marotta, T., Borrelli, R., & Mancini, M. (1993). Cardiovascular response to mental stress and to handgrip in children. The role of physical activity. *Japanese Heart Journal, 32*(5), 645–654. https://doi.org/10.1536/ihj.32.645

Forcier, K., Stroud, L. R., Papandonatos, G. D., Hitsman, B., Reiches, M., Krishnamoorthy, J., & Niaura, R. (2006). Links between physical fitness and cardiovascular reactivity and recovery to psychological stressors: A meta-analysis. *Health Psychology, 25*(6), 723–739. https://doi.org/10.1037/0278-6133.25.6.723

GBD 2016 Causes of Death Collaborators. (2017). Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: A systematic analysis for the Global Burden of Disease Study 2016. *The Lancet, 390*(10100), 1151–1210. https://doi.org/10.1016/S0140-6736(17)32152-9

Goodie, J. L., Larkin, K. T., & Schauss, S. (2000). Validation of Polar heart rate monitor for assessing heart rate during physical and mental stress. *Journal of Psychophysiology, 14*(3), 159–164. https://doi.org/10.1027//0269-8803.14.3.159

Jackson, E. M., & Dishman, R. K. (2006). Cardiorespiratory fitness and laboratory stress: A meta-regression analysis. *Psychophysiology, 43*(1), 57–72. https://doi.org/10.1111/j.1469-8986.2006.00373.x

Karthikeyan, P., Murugappan, M., & Yaacob, S. (2011). *A review on stress inducement stimuli for assessing human stress using physiological signals*. 2011 IEEE 7th International Colloquium on Signal Processing and Its Applications. https://doi.org/10.1109/cspa.2011.5759914

Krantz, D. S., & Manuck, S. B. (1984). Acute psychophysiologic reactivity and risk of cardiovascular disease: A review and methodologic critique. *Psychological Bulletin, 96*(3), 435–464. https://doi.org/10.1097/00006842-200105000-00020

Larson, M. R., Ader, R., & Moynihan, J. A. (2001). Heart rate, neuroendocrine, and immunological reactivity in response to an acute laboratory stressor. *Psychosomatic Medicine, 63*(3), 493–501. https://doi.org10.1097/00006842-200105000-00020

Larson, M. R., & Langer, A. W. (1997). Defensive hostility and anger expression: Relationship to additional heart rate reactivity during active coping. *Psychophysiology, 34*(2), 177–184. https://doi.org/10.1111/j.1469-8986.1997.tb02129.x

Lovallo, W. R., Pincomb, G. A., Brackett, D. J., & Wilson, M. F. (1990). Heart rate reactivity as a predictor of neuroendocrine responses to aversive and appetitive challenges. *Psychosomatic Medicine, 52*(1), 17–26. https://doi.org/10.1097/00006842-199001000-00002

Martikainen, S., Pesonen, A.-K., Lahti, J., Heinonen, K., Feldt, K., Pyhälä, R., … Räikkönen, K. (2013). Higher levels of physical activity are associated with lower hypothalamic-pituitary-adrenocortical axis reactivity to psychosocial stress in children. *The Journal of Clinical Endocrinology & Metabolism, 98*(4), E619–E627. https://doi.org/10.1210/jc.2012-3745

Matthews, K. A., Salomon, K., Brady, S. S., & Allen, M. T. (2003). Cardiovascular reactivity to stress predicts future blood pressure in adolescence. *Psychosomatic Medicine, 65*(3), 410–415. https://doi.org/10.1097/01.psy.0000057612.94797.5f

Matthews, K. A., Woodall, K. L., & Allen, M. T. (1993). Cardiovascular reactivity to stress predicts future blood pressure status. *Hypertension, 22*(4), 479–485. https://doi.org/10.1161/01.hyp.22.4.479

McCubbin, J. A., Cheung, R., Montgomery, T. B., Bulbulian, R., & Wilson, J. F. (1992). Aerobic fitness and opioidergic inhibition of cardiovascular stress reactivity. *Psychophysiology, 29*(6), 687–697. https://doi.org/10.1111/j.1469-8986.1992.tb02047.x

Murphy, J. K., Alpert, B. S., Willey, E. S., & Somes, G. W. (1988). Cardiovascular reactivity to psychological stress in healthy children. *Psychophysiology, 25*(2), 144–152. https://doi.org/10.1111/j.1469-8986.1988.tb00977.x

Palmero, F., Luis Díez, J., & Breva Asensio, A. (2001). Type A behavior pattern today: Relevance of the JAS-S factor to predict heart rate reactivity. *Behavioral Medicine, 27*(1), 28–36. https://doi.org/10.1080/08964280109595769

Parker, F. C., Croft, J. B., Cresanta, J. L., Freedman, D. S., Burke, G. L., Webber, L. S., & Berenson, G. S. (1987). The association between cardiovascular response tasks and future blood pressure levels in children: Bogalusa heart study. *American Heart Journal, 113*(5), 1174–1179. https://doi.org/10.1016/0002-8703(87)90931-8

Peronnet, F., & Szabo, A. (1993). Sympathetic response to acute psychosocial stressors in humans: Linkage to physical exercise and training. In P. Seraganian

(Ed.), *Exercise psychology: The influence of physical exercise on psychological processes* (pp. 172–217). New York: Wiley. Retrieved from https://www.wiley.com/en-us/Exercise+Psychology%3A+The+Influence+of+Physical+Exercise+on+Psychological+Processes-p-9780471527015

Roemmich, J. N., Lambiase, M., Salvy, S. J., & Horvath, P. J. (2009). Protective effect of interval exercise on psychophysiological stress reactivity in children. *Psychophysiology, 46*(4), 852–861. https://doi.org/10.1111/j.1469-8986.2009.00808.x

Roemmich, J. N., Smith, J. R., Epstein, L. H., & Lambiase, M. (2007). Stress Reactivity and Adiposity of Youth. *Obesity, 15*(9), 2303–2310. Retrieved from https://onlinelibrary.wiley.com/doi/full/10.1038/oby.2007.273

Saltin, B., & Grimby, G. (1968). Physiological analysis of middle-aged and old former athletes. *Circulation, 38*(6), 1104–1115. https://doi.org/10.1161/01.cir.38.6.1104

Seraganian, P., Szabo, A., & Brown, T. (1997). The effect of vocalization on the heart rate response to mental arithmetic. *Physiology & Behavior, 62*(2), 221–224. https://doi.org/10.1016/s0031-9384(97)00102-9

Sharpley, C. F. (2002). Heart rate reactivity and variability as psychophysiological links between stress, anxiety, depression, and cardiovascular disease: Implications for health psychology interventions. *Australian Psychologist, 37*(1), 56–62. https://doi.org/10.1080/00050060210001706686

Siegel, S. (1957) Nonparametric statistics, *The American Statistician*, *11*(3),13–19. https://doi.org/10.1080/00031305.1957.10501091

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643–662. Retrieved from https://pure.mpg.de/rest/items/item_2389918/component/file_2389917/content

Szabo, A., Brown, T. G., Gauvin, L., & Seraganian, P. (1993). Aerobic fitness does not influence directly heart rate reactivity to mental stress. *Acta Physiologica Hungarica, 81*(3), 229–237. Retrieved from https://europepmc.org/article/med/8197878

Szabo, A., Small, A., & Leigh, M. (1999). The effects of slow-and fast-rhythm classical music on progressive cycling to voluntary physical exhaustion. *Journal of Sports Medicine and Physical Fitness, 39*(3), 220–225. Retrieved from https://search.proquest.com/docview/202669485/fulltextPDF/43F37B0582594B61PQ/1?accountid=15870

Szabó, A., Péronnet, F., Frenkl, R., Farkas, A., Petrekanits, M., Mészáros, J., … Szabó, T. (1994). Blood pressure and heart rate reactivity to mental strain in adolescent judo athletes. *Physiology & Behavior, 56*(2), 219–224. https://doi.org/10.1016/0031-9384(94)90187-2

van Doornen, L. J. P., & de Geus, E. J. C. (1989). Aerobic fitness and the cardiovascular response to stress. *Psychophysiology, 26*(1), 17–28. https://doi.org/10.1111/j.1469-8986.1989.tb03127.x

World Medical Association. (2019). *WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects.* July 9, 2018. Retrieved from https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/

Received on August 06, 2020
Accepted on November 03, 2020