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Psychological effects of 50-meter swimming: does tempo manipulation matter?

Introduction

Swimming is one of the world's most popular recreational physical activities (Sports Marketing Surveys Inc., 2014), and it is also a popular competitive sport. In addition to its physical and cardiorespiratory benefits (Després, 2016; Mohr et al., 2014), swimming has numerous positive physiological (Oja et al., 2015; Tanaka, 2009) and mental health effects (Yfanti, Samara, Kazantzidis, Hasiotou, & Alexiou, 2014). Epidemiological studies suggest that after controlling for several influencing factors, the risk of mortality might be about 50% lower in swimmers in contrast to regular walkers, runners or joggers, and inactive individuals (Chase, Sui, & Blair, 2008). Based on the hedonic theory (Higgins, 1997), long-term commitment to swimming and other physical activities stems from the positive feeling states derived from exercise, which is an internal source of motivation.

The psychological benefits of swimming are well-known in the literature. Berger and colleagues showed that a single swimming session has immediate positive affective benefits (Berger & Owen, 1983, 1988, 1992a, b; Berger, Owen, & Man, 1993; Berger, Prapavessis, Grove, & Butki, 1997). For example, in an early work, Berger and Owen (1983) found that 58 college swimmers reported significantly less anger, confusion, depression, and more vigor after swimming than before. In a later study, mood changes in four forms of exercise were assessed on three different occasions; swimmers' tension and confusion decreased on the first instance, but no changes were observed on the second and third (Berger & Owen, 1988). The vanishing of the positive effects after the first swim was ascribed to ceiling effects due to elevated mood states at baseline in swimmers.

In a subsequent study with 37 college students taking yoga and swimming classes, the affective benefits of swimming, along with those of yoga, were further exposed (Berger & Owen, 1992a). The results were replicated in a cross-cultural investigation with US and Czech college swimmers (Berger et al., 1993). A later study with 48 young competitive swimmers (Berger et al., 1997) showed that a shorter duration training (abbreviated practice) was associated with positive changes in affect, while the regular practice time yielded no psychological benefits. Supporting these findings, a field study comparing recreational and competitive swimmers in their habitual training environment revealed that positive changes in affect occurred after recreational but not competitive swimming (Szabo et al., 2018). More recently, a 10-week longitudinal study showed that novice outdoor swimmers exhibited acute and chronic decreases in negative mood, increased well-being, and acute increases in their positive mood (Massey et al., 2020). The duration of the swimming sessions in these studies lasted for at least 20 min, except in the study by Massey et al., in which the sea immersion time was self-selected. The psychological effects of shorter bouts of swimming were not investigated to date.

The affective benefits of exercise may emerge after relatively short workouts, while control over the exercise intensity/duration may play an important role. For example, a literature review revealed that exercise performed at *self-selected* intensity improves well-being (Ekkekakis, 2009). Further, research has shown that psychological improvements might occur even after brief 10-minute bouts of physical exercise (Anderson & Brice, 2011; Hansen, Stevens, & Coast, 2001; Sullivan, Covington, & Scheman, 2010). Moreover, a later study reported that *core affect* has improved after only three minutes of very light exercise (Szabo, Gaspar, & Abraham, 2013). However, Szabo et al. (2013) measured core affect with a single-item 10-point Likert scale. Still, a more refined conceptualization by Russell (2003) describes core affect as a two-dimensional construct generated by affective valence (feelings of pleasure or displeasure) and activation (perceived arousal). Hence, core affect is a dynamic general feeling determined by a cluster of momentary interactions between pleasant/unpleasant feelings and arousal, which, as based on Russell's (1980) classical Circumplex Model of Affect, results in four quadrants: (1) high-arousal, pleasant affect (e.g., excitement), (2) high-arousal, unpleasant affect (e.g., distress), (3) low-arousal, unpleasant affect (e.g.,

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depression), or (4) low-arousal, pleasant affect (e.g., contentment).

Albeit one of the most popular recreational physical activities, a brief swimming episode's psychological benefits have not yet been examined. However, deriving psychological pleasure in the early phase of exercise might be essential in perseverance based on the hedonic theory (Higgins, 1997). Indeed, swimming is often connotated as "boring" (Beattie, Alqallaf, Hardy, & Ntoumanis, 2019; Gould, Feltz, Horn, & Weiss, 1982; Hollander & Acevedo, 2000), but early experienced pleasure after the first laps may buffer monotony. Attention-distracting interventions like listening to music while swimming could further alleviate boredom and act as an ergogenic (synchronization to music's tempo) or motivational aid. Consequently, many swimmers listen to music to make their exercise sessions more enjoyable (Karageorghis et al., 2013).

Karageorghis, Terry, and Lane (1999) proposed that four aspects of music are influential in exercise: (a) tempo, (b) musicality, (c) cultural impact, and (d) association. Tempo is the rhythm or speed of the music, which can be *objectively* assessed in beats per minute. Musicality reflects pitch-related elements, such as harmony and melody. Further, the cultural impact mirrors the pervasiveness of music in a given society. Finally, association describes the mental connection between music and various experiences. The four aspects surface in a hierarchical order in which the tempo is the most important, while the association is the least significant motivational feature (Karageorghis et al., 1999). Karageorghis and Terry (1997) suggested that during submaximal aerobic activities, such as swimming, people may synchronize their movement to musical tempo. This contention has received partial support in an electroencephalographic study of runners (Schneider, Askew, Abel, & Strüder, 2010).

The music's tempo or rhythm can be considered an objective and reliable musical index (London, Burger, Thompson, & Toiviainen, 2016). Indeed, this musical feature is expressible numerically in contrast to the other musical elements. Therefore, the tempo provides a common denominator for research connecting music and exercise. However, the tempo of the music is unlikely to elicit an affective response (Khalfa, Roy, Rainville, Bella, & Peretz, 2008). Still, an augmenting tempo influences arousal (Husain, Thompson, & Schellenberg, 2002), which represents the *activation* dimension of core affect in the Circumplex Model of Affect.

Although a study reported that listening to preferred music for 5 min *before* a 200 m freestyle trials has shortened (1.44%) the swimming time (Smirmaul, Dos Santos, & Da Silva Neto, 2014), research on music *during* swimming is limited to three published works (to the best knowledge of the authors). One study examined 24 competitive swimmers and reported better performance on 50 m and 800 m trials in response to preferred music, while the subjective enjoyment of swimming was not affected by music (Tate, Gennings, Hoffman, Strittmatter, & Retchin, 2012). Another study, examining 26 collegiate swimmers, found that both motivational and neutral music, played at 130 beats per minute (bpm), improved the results on 200 m freestyle time trial (2%) compared to the no-music control session. However, no differences in feeling states, arousal, or core affect were disclosed (Karageorghis et al., 2013). These two studies did not test the changes in exercise-induced affective states directly, and both were conducted in competitive environments (based on time trials) in freestyle swimming.

The third study examined the effects of preferred music, ranging in tempo from 125–140 bpm, on performance, heart rate, perceived exertion, and affect during six 200 m laps of freestyle swimming at a self-selected pace in 20 young recreational swimmers (Olson, Brush, O'Sullivan, & Alderman, 2015). The findings revealed that compared to the no-music condition, participants swam faster in the presence of music. Furthermore, while music did not affect the perceived exertion, it was associated with increased arousal and affect, reflecting an increase in core affect. Still, whether a shorter or a very brief episode of recreational swimming also improves affect similarly, it remains open to further experimental scrutiny. In addition, whether different forms of swimming produce comparable affective benefits is currently also unanswered.

Based on the hedonic theory (Higgins, 1997), we conjectured that the actual *pursuit of pleasure* (which is the gist of this theory) starts with the decision to go for a swim, which could manifest in early acute psychological change even after a very brief period (i.e., 50 m lap). Furthermore, based on past research, we anticipated the natural synchronization of the movement to the music (Karageorghis & Terry, 1997; Large, 2000; Schneider et al., 2010). Therefore, we presumed that steady tempo drum beats at 72 bpm would generally decrease lap time by stimulating a faster (vs. habitual) stroke rate (strokes/min) in an attempt to synchronize movement to the pace of the drumbeat. Recreational swimmers, in general, can be expected to manifest lower stroke rates than elite swimmers, who also perform fewer than 70 strokes per minute in 50 m freestyle and, obviously, fewer strokes in breaststroke style (Dadashi, Millet, & Aminian, 2015; Dragunas, Dickey, & Nolte, 2012; Finis Inc., 2021). We also thought that a progressively augmenting tempo would shorten lap time by increasing the stroke rate in parallel with the rhythm. We based this presumption on a past investigation showing that increasing the music tempo by switching from slow-tempo to fast-tempo music *during* ergometer cycling resulted in more work, without proportional changes in heart rate, due to attention-capturing and arousal effects of the tempo switch (Szabo, Small, & Leigh, 1999).

Therefore, the objectives of this field research were to investigate the psychological effect of a 50 m swim in either freestyle or breaststroke among recreational swimmers and to determine whether steady and augmenting tempo manipulation impact affective measures, swimming time, heart rate, and perceived exertion. We relied on Large's model (2000) and neurological evidence (Schneider et al., 2010) in assuming that swimmers will tend to synchronize their movement to the external tempo

Abstract

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Psychological effects of 50-meter swimming: does tempo manipulation matter?

Abstract

Swimming is one of the world's most popular recreational exercises and sports. Scholastic writings consistently demonstrate their physical and mental benefits. In contrast to earlier works, the current field experiment examined whether an ultrashort 50 m bout of swimming could yield positive changes in affect. It also tested whether swimming aided by steady and augmenting tempo (drumbeats) could generate additional psychological benefits, abbreviate swim time, and increase heart rate and perceived effort. Forty-eight adults completed freestyle or breaststroke 50 m laps in three counterbalanced conditions. The tempo manipulation did not influence any of the measures. However, simmers' core affect increased as manifested in higher self-reported feeling states and arousal, regardless of the experimental condition. Similarly, participants' positive affect was also increased after 50 m laps, and it was higher in breaststroke than freestyle swimmers throughout the study. No changes emerged in negative affect due to floor effects. These results show that core and positive affect improve after *less than one minute* of swimming, which might be the shortest ever exercise interval associated with positive psychological changes in recreational exercise. Several possible explanations could account for these findings. Therefore, further research is needed to identify the specific mechanism(s) responsible for the current results.

Keywords

Aquatic sport · Arousal · Breaststroke · Exercise · Feeling state · Freestyle

(Hallett & Lamont, 2016). Therefore, we opted for steady and augmenting-tempo monotonous, almost neutral tempo manipulation (metronome-based, exact-tempo drumbeats). Since performance but not enjoyment changed in response to 50 m swimming (Tate et al., 2012), and since the psychological benefits are more likely to occur in recreational than competitive swimming (Olson et al., 2015; Szabo et al., 2018), we adopted a 50 m swimming intervention. To compare possible stroke-related differences, we examined both freestyle and breaststroke swimming. Unlike two earlier studies with competitive swimmers and in accord with Olson et al. (2015) with recreational swimmers, instead of time trials, we examined the effects of tempo by letting participants swim in their preferred style and at their desired exercise intensity (Ekkekakis, 2009) in all three conditions. Like Karageorghis et al. (2013), we used a mixed-model research design having one within-participants factor (swimming conditions) and two between-participants factors (swim type and gender).

Hypotheses

1. A single bout of 50 m swim is enough to improve affect and arousal in both freestyle and breaststroke swimming at the desired exercise intensity.
2. Augmenting tempo dictated by drum beats, reduces lap time and increases heart rate and perceived exertion in contrast to a control session.

Methods

Ethics

We obtained ethical approval for this study from the Research Ethics Committee of the Faculty of Education and Psychology at ELTE Eötvös Loránd University, Budapest, Hungary. In addition, this research conformed to the ethical standards of the British Psychological Society (2014) and that of the World Medical Association's Declaration of Helsinki (2013).

Participants

The required sample size (n) was calculated with the G*Power (version 3.1.9.7; Heinrich-Heine-Universität Düsseldorf, Germany) software (Faul, Erdfelder, Lang, & Buchner, 2007) for repeated measures F-tests, within factors multivariate analysis of variance (MANOVA). This calculation was based on power $(1-\beta)=0.95$, a medium effects size $(f)=0.25$, and $\alpha=0.05$, with four groups (two genders, two swimming styles) and four measurements (baseline, control, steady tempo, augmenting tempo) with an assumed correlation of 0.5[1] between the dependent measures. Based on this analysis, the calculated sample size was 40. We aimed to recruit ten more participants than the required minimum sample size, to account for the possible drop-out and other losses.

Using a systematic (simple) randomization method (Suresh, 2011), we solicited every third person coming for a recreational swim to a large urban swimming complex with a 50 m swimming pool to take part in the study. The recruitment continued until 50 participants consented in writing to participate. One of eight swimming lanes was reserved for the current study when testing. Two participants did not wish to conform to one of the two optional swimming styles (freestyle or breaststroke) and, therefore, withdrew their consent to participate. Consequently, the current research is based on 48 participants aged 18–68 years (mean [M] = 45.44 ± standard deviation [SD] = 14.55); 27 women and 21 men. Slightly more than half of the participants (27) chose to complete the study in freestyle swimming, whereas 21 swam in the breaststroke style. **Table 1** illustrates the sample's characteristics.

Materials and methods

Psychological measures

The momentary feeling state was assessed with the Feeling Scale (FS; Hardy & Rejeski, 1989). The scale is rated from −5 to +5, reflecting feeling states from very bad to very good. The subjective perception of arousal was determined with the Felt Arousal Scale (FAS; Svebak & Murgatroyd, 1985), which is rated on a 6-point Likert scale ranging from 1 (very low arousal) to 6 (very high arousal). Affect was measured with the Physical Activity Affect Scale (PAAS; Lox, Jackson, Tuholski, Wasley, & Treasure, 2000). This

[1] These correlations were actually higher.

Measure	Men ($n = 21$) Mean (SD)	Women ($n = 27$) Mean (SD)
Age, years	44.95 (16.3)	45.81 (13.03)
Height, cm	179.52 (5.00)	169.15 (6.04)
Weight	86.76 (13.69)	73.59 (17.13)
Body mass index (BMI)	26.92 (4.15)	25.75 (6.06)
Reported weekly exercise, h	4.67 (2.24)	3.07 (2.07)

Table 1 Characteristics of the participants by gender; means and standard deviations

n number of participants, *SD* standard deviation

instrument has four subscales: (1) positive affect, (2) negative affect, (3) physical exhaustion, and (4) tranquillity. Sample items in an order are the following: upbeat, miserable, worn-out, and relaxed. The PAAS is rated on a 5-point Likert scale ranging from 0 (do not feel) to 4 (feel very strongly). In the current study, we added a constant (1) to avoid working with zeros; thus, the range of ratings was changed from 1 to 5. The PAAS has excellent psychometric properties (Lox et al., 2000). In the current study, the internal consistencies (Cronbach's alpha [α]) of the four subscales were 0.75 (positive affect). 0.98 (negative affect), 0.84 (physical exhaustion) and 0.76 (tranquillity) as measured after the control swim-session in the 48 participants. Borg's 11-point Perceived Exertion scale (Borg, 1998) was used to assess perceived effort after the swimming laps.

Tempo manipulation and associated instruments

Steady tempo and augmenting tempo drumbeats were created with the online program Drum Machine (Onemotion, 2019). The beats were composed of two drums, one named Kick and another named Snare. For steady tempo drum beats, the metronome was set to 72 bpm, which was suggested to be a slow tempo for stationary cycling (Szabo et al., 1999) and rowing (Rendi, Szabo, & Szabó, 2008). However, it can be considered a fast tempo in swimming (Finis Inc., 2021), depending on the number of bpm synchronized to a stroke (Mooney et al., 2017). Other settings of the drum program were maintained. Accordingly, the recording volume was set at 80 dB, beat subdivision B/4, in the first subdivision on the 1st place Kick and in the 2nd subdivision Snare ones, and so on for all eight subdivisions. Recording took place in a silent studio using a Lenovo lG580 laptop in conjunction with the Audacity program. The beats were recorded for 2 min.

The augmenting tempo drum beats were created similarly; every 10 s the pace was accelerated by 36 bpm. This fast pace was deemed appropriate to allow participants to experience four to five increments during a 50 m lap. The fastest tempo was 252 bpm, which could be reached after 50 s, and it was preserved until the end of the 2 min recording. Subsequently, a countdown of 25 s was recorded with the two different information for the two versions of drum beats "A" (steady tempo) and "B" (augmenting tempo), respectively. The countdown was set with the same Audacity program and proceeded the drum beats. All were played with an MP3 player (Type: Nabaiji, Model No. 8385885, Nabaiji Electronics, China) at an average of 60 decibels as measured with the Decibel X application (SkyPaw Co. Ltd., Hoàn Kim, Hà Ni, Vietnam).

Physiological measures and timer

A Polar (model OH1 Optical Heart Rate Sensor BLK GEN., serial number 92070523 manufacturer Polar Electro Oy, Kempele, Finland) heart rate (HR) monitor was used for the continuous recording of the HR. An iPhone 8 (smartphone) Stopwatch Application (Timer) was used to record the duration of the swim and the length of the pauses between the laps.

Procedure

After participants received all the information relevant to the study and signed the informed consent form, they were provided with a fitted earplug and MP3 player. The latter was clamped onto the strap of the goggles behind the head. The heart rate monitor was mounted on the exterior of the left upper arm about 10 cm from the elbow. The timer and the heart rate sensor were started simultaneously. The former was used to measure the swim times and the recovery intervals between the laps. Following habituation to the drumbeats and a few warm-up exercises (arm, shoulder, trunk rotations), the participants entered the pool, and baseline measures were obtained at least after 1 min following immersion in the water. During this period, the researcher familiarized the participants with the tests and explained that answers should be based on the first hunch as the momentary feelings count without being classified as wrong or right. Then, the experimenter read the questions and solicited verbal answers to each item on the corresponding rating scale for the psychological variables. After verbal completion, the questionnaire was shown to the participant for endorsement. Subsequently, fitting earplugs of the MP3 player were inserted into the participant's ear, and the MP3 player was turned on. The swimmer then listened to a version A or B announcement that was selected depending on the condition (steady tempo or augmenting tempo), and then the countdown began. In version C (control condition), the experimenter did the countdown. Water temperature was between 25 and 27 °C.

Participants swam three 50 m laps in a partially counterbalanced order to account for practice effects. The sessions were designed so that each swimming condition assumed either the first, second, or third intervention order sequentially in a block of three participants. Swimmers were free to select their preferred exercise intensity like in the Olson et al. (2015) study, which increases the external validity of the results (Karageorghis & Priest, 2012). The first participant swam in ABC order (A = steady tempo, B = augmenting

Table 2 Descriptive statistics and the results of Greenhouse–Geisser-corrected univariate F tests of the six psychological measures before and after three swimming conditions ($n = 48$)

Measure	Baseline	Swimming without drumbeats	Swimming with steady tempo beats	Swimming with augmenting tempo beats	*F*	*p*	Effect size (ηp^2)
Feeling	3.42 (1.27)[a]	4.04 (1.20)[b]	4.02 (1.16)[b]	4.06 (1.14)[b]	5.79	0.002	0.12
Arousal	4.08 (0.99)[a]	5.19 (0.84)[b]	5.19 (0.89)[b]	5.08 (0.85)[b]	25.73	< 0.001	0.37
Positive affect	3.57 (0.74)[a]	4.16 (0.65)[b]	4.24 (0.73)[b]	4.24 (0.72)[b]	27.34	< 0.001	0.38
Negative affect	1.17 (0.41)	1.07 (0.32)	1.13 (0.37)	1.13 (0.46)	1.28	NS	–
Physical exhaustion	1.84 (0.90)	1.99 (0.93)	1.87 (0.91)	1.77 (0.84)	0.89	NS	–
Tranquillity	3.63 (0.69)	3.56 (0.94)	3.65 (0.99)	3.61 (1.03)	0.26	NS	–

NS Not Significant, *M* mean, *SD* standard deviation

[a,b]Bonferroni corrected pairwise comparisons indicated that compared to preswimming baseline ([a]), in all three swimming conditions ([b]) feeling state, felt arousal, and positive affect were statistically significantly higher ($p < 0.05$)

Table 3 The results of the Bonferroni corrected ($\alpha = 0.008$) one-sample t-tests testing the statistical significance of the difference in feeling states and felt arousal scores compared to baseline (0) in three 50 m swimming conditions

	t	Df		95% CI of the difference	
			p	Higher	Lower
DF1	3.49	47	< 0.001	0.604	0.256
DF2	3.41	47	< 0.001	0.646	0.265
DF3	3.51	47	< 0.001	0.625	0.268
DA1	7.38	47	< 0.001	1.104	0.803
DA2	6.35	47	< 0.001	1.000	0.683
DA3	7.86	47	< 0.001	1.104	0.822

D difference score, *F* feeling state, *A* arousal, *1* steady tempo, *2* augmenting tempo, *3* control, *95% CI* confidence interval

tempo, and C = control, no tempo manipulation). The second participant swam in BCA order, and the third participant swam in CAB order. This cycle was repeated for the following three participants until all 48 were tested. Swimmers could choose to swim three 50 m laps in either freestyle or breaststroke. A 4 min recovery between the laps was deemed sufficient in recreational swimming based on earlier work using 3–5 min rest periods between trials in competitive swimmers (Tate et al., 2012). During this period, participants indicated their perceived exertion and responded to psychological questionnaires (14 items, lasting less than 1 min) and, subsequently, could stretch in the water but not swim.

Statistical analyses

First, we calculated the descriptive statistics for demographic and dependent measures. Then, differences between breaststroke and freestyle swimmers were tested with the chi-squared (χ^2) test and multivariate analysis of variance (MANOVA). Subsequently, two mixed model multivariate repeated measures analyses of variance (MRM-ANOVA) were employed. The first hypothesis was tested with a 2 (swim type) × 2 (gender) × 4 (time) MRM-ANOVA including six dependents measures (perceived arousal, feeling state, positive affect, negative affect, physical exhaustion, and tranquillity). The second hypothesis was examined with a 2 (swim type) × 2 (gender) × 3 (condition) MRM-ANOVA with three dependent measures (duration of swim, heart rate, perceived effort). Finally, the changes in *core affect* (Russell, 2003) were tested with Bonferroni-corrected one-sample t-tests using the baseline to postintervention (i.e., post-swim scores in each swimming condition—baseline) *change or difference scores* in feeling states and felt arousal. These results were then graphically examined by plotting the intersection of the mean affective valence (feeling states) and activation (arousal) at baseline and after each swimming condition, reflecting the changes in *core affect* after three swimming conditions. Statistical analyses were performed with the Statistical Package for Social Sciences (SPSS v. 25, IBM, Armonk, NY, USA) software.

Results

Breaststroke vs. freestyle swimmers

An initial χ^2 test indicated that there was statistically no significant difference ($\chi^2(1) = 3.50$, $p > 0.05$) in the gender distribution of those participants who chose to complete the 50 m swimming laps in freestyle (15 men, 12 women) and those who opted for the breaststroke swimming (6 men and 15 women). In addition, these two groups did not differ in age, reported weekly hours of exercise, and any dependent measures obtained before swimming (baseline), except positive affect that was higher ($M = 3.83 \pm SD = 0.75$) in breaststroke swimmers than freestyle swimmers ($M = 3.37 \pm SD = 0.68$; $F(1.46) = 4.87$, $p = 0.03$ effect size (Cohen's d) = 0.64). The weekly hours of exercise did not correlate with positive affect at baseline, and the correlations were also not significant when examined separately for breaststroke swimmers and freestyle swimmers.

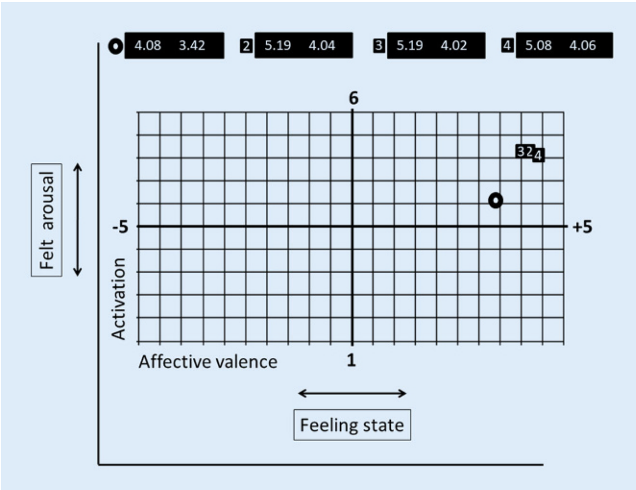

Fig. 1 ▲ Shift in core affect (intersection of mean *felt arousal* and mean *feeling states).* The exact mean values are shown in the *black squares* on the top of the graph in three swimming conditions (*2* control, *3* steady tempo drum beats, and *4* augmenting tempo drum beats versus the preswim baseline [*circle*]). Regardless of the intervention, all 50 m swimming bouts shifted the already positive core affect into an even more favorable position. This shift was statistically significant ($p < 0.001$), based on the magnitude of the differences between pre- and postswimming scores (change scores), in feeling states and felt arousal (**Table 3**) in all three 50 m laps

First hypothesis

The first MRM-ANOVA tested the null hypothesis that the six psychological measures do not differ at the four sampling times and between freestyle and breaststroke swimmers and men and women. This test yielded a statistically significant multivariate *within-participants* time (pre- to postswimming) main effect (Pillai's trace = 0.765, F [18, 27] = 4.87, $p < 0.001$, partial ETA squared [ηp^2] = 0.77, power [$1-\beta$] = 1.00), but no time by swim type or time by gender interaction. Descriptive statistics and the summary of the univariate tests, which revealed statistically significant increases in feeling state, felt arousal, and positive affect, are presented in **Table 2**.

A series of one-sample t-tests of the change (delta) scores, examining the magnitude of changes from baseline (0), in feeling states and felt arousal were statistically significant even after Bonferroni corrections (new minimum acceptable alpha [α] = 0.008; **Table 3**). The changes in core affect, represented by the intersection of the mean feeling state and felt arousal scores in the three swimming conditions, are shown in **Fig. 1**. Based on the statistically significant results obtained in the change scores (**Table 3**), the positive shift visible in **Fig. 1** is statistically significant in each swimming condition ($p < 0.001$).

The first MRM-ANOVA also revealed a statistically significant *between-participants* multivariate effect for swim type (Pillai's trace = 0.278, F [6, 39] = 2.51, $p = 0.038$, $\eta p^2 = 0.29$, $1-\beta = 0.772$). The univariate test revealed that this multivariate effect was due to a statistically significant difference in the overall (i.e., across four sampling times) positive affect (F [1, 44] = 5.45, $p = 0.024$, $\eta p^2 = 0.11$, $1-\beta = 0.627$) between freestyle swimmers (M = 3.87, SD = 0.57) and breaststroke swimmers (M = 4.28, SD = 0.63). The two groups did not differ in other psychological measures. Finally, no statistically significant differences were found in psychological measures between genders.

Second hypothesis

The second MRM-ANOVA, testing the research hypothesis that swimming time will decrease, while heart rate and perceived effort will increase in the tempi manipulated 50 m laps compared to the control session, yielded no statistically significant results. The descriptive statistics and univariate results of this test are shown in **Table 4**. Finally, there was a high positive correlation ($r \geq 0.98$, $p < 0.001$) between the three 50 m swimming times.

Discussion

Supporting and expanding the findings of Olson et al. (2015), a noteworthy novel contribution of this field research is that core affect can improve after less than 1 min (**Table 4** and **Fig. 1**) of swimming. Although these changes may be short-lived, to our knowledge, this is the shortest ever exercise time that may be associated with improved psychological measures. The second shortest exercise-induced improvement in core affect occurred after 3 min (Szabo et al., 2013). Still, the form of exercise was different, and core affect measures were obtained with a single item scale rather than being conceptualized as the two-dimensional product of feeling states and felt arousal (Russell, 2003). This finding raises an essential question for this field of empirical research: What is the psychophysiological mechanism that could trigger the acute changes in affect after such a brief exercise period?

While the answer begs for further research, three explanations, possibly not independent of each other, might account for the acute changes in affect. The first one may be related to increased levels of arousal justified by the objective but crude sympathetic index (heart rate) and the self-perceived levels of arousal. For example, according to Thayer (1990), even a brisk walk could augment arousal and simultaneously improve the subjective feeling states. Thus, a sudden change in arousal that could be triggered even by a change in body position (Szabo, 1993) augments the core affect's *activation* dimension (**Fig. 1**). However, increased arousal may not merely be due to movement. For example, research has shown that tempo manipulation also increases arousal (Xie et al., 2010). Indeed, we expected faster swim times in the current study due to increased arousal (Szabo et al., 1999) and associated movement synchronization with the increasing tempo (Karageorghis et al., 2013). However, the results indicate that the im-

Table 4 Descriptive statistics and the results of Greenhouse–Geisser-corrected F tests of the swimming time, heart rate, and perceived exertion in three swimming conditions ($n=48$)

Measure	Swimming without drumbeats	Swimming with steady tempo beats	Swimming with augmenting tempo beats	*F*	*p*
50 m lap time (s)	56.81 (19.36)	56.70 (19.93)	56.26 (19.45)	0.39	NS
Mean heart rate (BPM)	115.04 (15.34)	115.17 (17.47)	117.27 (16.80)	0.48	NS
Perceived effort (/10)	6.21 (2.10)	5.73 (2.03)	6.15 (1.99)	1.11	NS

NS Not significant, *M* mean, *SD* standard deviation, *BPM* beats per minute

proved affective measures were not due to the tempo manipulation-induced arousal because the positive changes in manipulated sessions did not differ from the control session. Therefore, the increased arousal explanation can only be related to the engagement in swimming per se.

The second mechanism relates to the two-dimensional model of core affect (Russell, 2003), which connects behavioral intention and the anticipated outcome interlinked via the expectancy theory (Vroom, 1964), fitting in with the theory of planned behavior (Ajzen, 1991). Unfortunately, we did not gauge expectancy before swimming, but research shows that planned exercise behavior is associated with positive expectancy that affects postexercise affect (Anderson & Brice, 2011; Kwan, Stevens, & Bryan, 2017; Szabo, 2013). A third explanation may be that since participants knew that they were part of an experiment, they acted differently than they usually would, which might have surfaced in the results as a Hawthorne effect. Still, because we did not observe differences in heart rate, perceived effort, and time to complete the three 50 m laps, we may suspect that, in general, the swimmers did not attempt to please the experimenter. Nevertheless, the Hawthorne effect might have affected the data. Furthermore, although we found increased core affect in contrast to a baseline taken in the water (**Fig. 1** and **Table 3**), this baseline is not a genuine preswimming baseline because it might already contain the effects of water immersion and temperature change. Consequently, future studies should also obtain a baseline measure before swimmers enter the pool to assess the affective impact of water immersion and temperature change.

It is worth noting that the core affect in this field experiment was already in the *high-activation, positive valence quadrant* (**Fig. 1**) at baseline, reflecting excitement (Russell, 1980). A further increase in core affect, confirmed by the statistically significant increases in both feeling states and arousal in all conditions (**Table 3**), is relatively novel. It indicates that recreational swimmers exhibit positive core affect at a baseline (which could be artificial as per the above discussion but could be related to expectancy effects, too) that could become even more positive after swimming. However, future works should untangle the *specific cause(s)* of this positive shift because it remains unclear whether it resulted from increased arousal, water immersion, pressure change, floating, change in temperature, swimming (exercise) itself, placebo effect, or a combination of these.

In addition to improved core affect, supporting the psychological benefits of the brief swim, *positive* affect also increased after the three 50 m laps compared to baseline. However, no significant changes emerged in negative affect due to swimming. This latter, however, had a too low baseline value (close to the minimum value of 1) from which a further decrease would be difficult or impossible to detect, which could be attributed to a *floor effect* (**Table 2**). Furthermore, no differences were found in the reported physical exhaustion between the four sampling times, supported by almost identical lap times (reflecting self-selected workloads) and the high correlations between the lap times. It is also possible that swimming a 50 m lap at self-selected effort was not perceived as tiring by the participants, mainly because they could swim at their pace. Despite, the mean perceived exertion scores on the Borg scale (**Table 4**) close to and above 6 (reflecting the borderline between "hard" and "very hard") showed that participants perceived that they worked out "hard" during the laps, they were unlikely to be exhausted after the short bout of swimming. Finally, no differences in tranquillity were observed between the three swimming laps and compared to preswim baseline measures.

Tempo manipulation with steady and augmenting drumbeats did not affect the psychological measures. These findings match those obtained by Tate et al. (2012), who found that subjective enjoyment of swimming was not affected by music during 50 m or 800 m swimming laps. However, these authors used self-selected music with no control over the tempo. They also agree with the results of Karageorghis et al. (2013), revealing no difference in feeling states and felt arousal between laps completed with and without music. These authors reported an overall performance increase of 2% in 200 m swimming laps, which contrasts with the current results showing no overall improvement in lap times associated with tempo manipulation. However, it should be emphasized that the natural variation in pace (stroke rate, stroke length, force, etc.) is likely higher in recreational than in competing swimmers.

Compared to the only study with recreational swimmers, our findings are in discord with the results obtained by Olson et al. (2015), who reported faster swimming and increased heart rate during music versus the control session after six assessments following every 200 m of 1200 m self-paced swimming episode. It should be noted that Olson et al. studied young recreational swimmers compared to the large age range examined here, and our steady tempo was almost only half of that used by Olson and colleagues. In contrast, the increasing tempo peaked at about 100 bpm higher than in their study. Their music also contained melody and harmony, permitting association and cultural effects (Karageorghis et al., 1999), which could have had an effect above and beyond the tempo on the swimming bouts. Indeed, the here-employed mechanically devised drumbeats have a constant and repetitive tempo (Rietveld, 2018) that is unlikely to influence core affect (Khalfa et al., 2008). Last, measures were taken after 200 m rather than after 50 m, like in this study, which could reflect the effects of a more prolonged swim.

Apart from exposing the positive effects of an ultrashort swim on the core affect, the current study's other novel contribution is that positive affect, regardless of interventions, was greater in breaststroke swimmers than freestyle swimmers. Unfortunately, no literature could support or refute these findings because the acute psychological benefits of the two swimming styles have not been compared to date. Should such differences exist, breaststroke could promote mental health, but the genuine psychological differences between the two strokes need further investigation since these findings may have occurred simply by chance, given that the two groups already differed in positive affect at baseline.

Limitations

Employing simple randomization instead of random sampling is one of the limitations of the current work. Using sequential (partial) rather than full counterbalancing is another limitation, but since no intervention effects have emerged in this case, it did not affect the presented results. Another limitation is that we did not measure stroke rates and associated measures like stroke length, which could have changed due to the intervention despite the lack of changes in other variables. Therefore, future studies should also measure these variables. A further limitation is the absence of a proper control condition, even though it is difficult to operationalize a "true" control condition for swimming. Furthermore, participants knew they would complete their usual swimming after research participation, which might be another limitation. Finally, missing critical questions, one about the appraisal of the interventions and another about the associated anticipation, is a further shortcoming of the current study, which begs for clarification in future works.

Conclusions

This field experiment shows that the affective benefits of swimming emerge after less than one minute. However, the induced changes may be short-lived. Further, the study does not elucidate the mechanism(s) responsible for the observed quick psychological improvement. The results also show that recreational swimmers already exhibit low negative affect and high positive affect upon entering the water, at the beginning of the study, with breaststroke swimmers demonstrating even more positive affect than freestyle swimmers. However, these differences are subject to future scrutiny because they may have occurred by chance. Furthermore, there were no gender differences in this study. Finally, adding or increasing music tempo did not influence the 50 m lap time, HR, or perceived effort. The shift in the core affect, manifested by improved feeling states and higher felt arousal, has occurred after each 50 m swimming lap.

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Declarations

Conflict of interest. K. Ábel, A. Szabó Rausz and A. Szabo declare that they have no competing interests.

This study was conducted in accord with the ethical standards indicated in the *Ethics* subsection at the beginning of the Methods section.

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