# Heart Rate Responses of High School Students Participating in Surfing Physical Education

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## Abstract

Bravo, MM, Cummins, KM, Nessler, JA, and Newcomer, SC. Heart rate responses of high school students participating in surfing physical education. *J Strength Cond Res* 30(6): 1721–1726, 2016—Despite the nation's rising epidemic of childhood obesity and diabetes, schools struggle to promote physical activities that help reduce risks for cardiovascular disease. Emerging data suggest that adopting novel activities into physical education (PE) curriculum may serve as an effective strategy for increasing physical activity in children. The purpose of this investigation was to characterize activity in the water and heart rates (HRs) of high school students participating in surf PE courses. Twenty-four male ($n = 20$) and female ($n = 4$) high school students (mean age = 16.7 ± 1.0 years) who were enrolled in surf PE courses at 2 high schools participated in this investigation. Daily measurements of surfing durations, average HR, and maximum HR were made on the students with HR monitors (PolarFT1) over an 8-week period. In addition, HR and activity in the water was evaluated during a single session in a subset of students ($n = 11$) using a HR monitor (PolarRCX5) and a video camera (Canon HD). Activity and HR were synchronized and evaluated in 5-second intervals during data analyses. The average duration that PE students participated in surfing during class was 61.7 ± 1.0 minutes. Stationary, paddling, wave riding, and miscellaneous activities comprised 42.7 ± 9.5, 36.7 ± 7.9, 2.9 ± 1.4, and 17.8 ± 11.4 percent of the surf session, respectively. The average and maximum HRs during these activities were 131.1 ± 0.9 and 177.2 ± 1.0 $b\cdot min^{-1}$, respectively. These data suggest that high school students participating in surf PE attained HRs and durations that are consistent with recommendations with cardiovascular fitness and health. In the future, PE programs should consider incorporating other action sports into their curriculum to enhance cardiovascular health.

**Key Words** paddling, cardiovascular, action sports

## Introduction

It is well documented that physical activity levels in adolescents (12–19 years old) have decreased over the last several decades (1). This has contributed to increased rates of childhood obesity and type II diabetes in youth across the United States (2,3). For this reason, the Centers for Disease Control (CDC) and the American College of Sports Medicine (ACSM) recommend that all children participate in 60 minutes or more of moderate-intensity physical activity daily (4). The CDC also considers middle and high school physical education (PE) curriculums to be an important component in achieving adequate levels of physical activity in adolescents (5). Unfortunately, within the United States, it has been reported that only 49% of high school students are enrolled in PE and, of these students, only 27% participate in PE daily (6). Furthermore, data suggest that only 8% of adolescents meet the physical activity requirements recommended by the ACSM and CDC (7). Based on these data, it is clear that adolescents are not meeting satisfactory levels of physical activity, and novel strategies of engaging adolescents in exercise are needed.

Participation in nontraditional forms of physical activity is growing in popularity among high school aged students (8). Specifically, data suggest that traditional sports' participation has decreased among adolescents, whereas participation in "action" or "extreme" sports has increased over the last decade (9). For this reason, many high schools in coastal Southern California have adopted surfing into the PE curriculum as a strategy to increase participation in physical activity. This strategy is based on evidence that suggests that students are more engaged in PE when they are provided with activities that they perceive as novel and enjoyable (10). Unfortunately, there is currently a paucity of data evaluating the appropriateness of having surfing as a component of the PE curriculum in a high school setting.

There are many factors that go into having a program of instruction as part of the PE curriculum. One important factor in evaluating surf PE curriculum is to determine

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**Table 1.** Subject characteristics for protocols 1 and 2.

| Study | *n* | Age (y) | Height (m) | Weight (kg) | Years surfing | Hours surfing/week |
|---|---|---|---|---|---|---|
| 1 | 24 | 16.7 ± 1.0 | 1.74 ± 0.10 | 65.6 ± 10.7 | 5.0 ± 2.7 | 12.3 ± 7.5 |
| 2 | 11 | 16.7 ± 1.3 | 1.77 ± 0.12 | 63.0 ± 9.9 | 4.5 ± 3.1 | 8.3 ± 3.6 |

whether exercise intensity, as assessed by heart rate (HR), meets the ACSM's recommendations for both cardiovascular fitness and weight management. Support for this can be derived from data collected in competitive surfers, which reported that paddling during competition comprises approximately 50–60% of the surf session and elicits HRs that have been shown to increase cardiovascular fitness and health (11,12). It is unclear whether these findings are specific to the single event in which the data were collected in the competitive surfers or generalizable to a population of recreational surfers participating in a surf PE curriculum. Given differences in motivation and environmental factors in a competitive setting, one can speculate that HRs obtained during a multiple-day competition from professional surfers are likely not representative of recreational surfers participating in a semester (8 weeks) long surf PE class. Therefore, the purpose of this investigation was to characterize activity in the water and HRs of high school students participating in surf PE courses over an 8-week period. We hypothesized that participation in surf PE activities (stationary, paddling, wave riding, and miscellaneous) would elicit HRs that meet the ACSM duration and HR recommendations for cardiovascular fitness and health.

## Methods

### Experimental Approach to the Problem

No studies have examined the heart rate response and activity profile of students participating in a surf PE curriculum. In this study, students' heart rates and surfing activity were evaluated daily while participating in an eight week high school surfing PE curriculum.

### Subjects

Twenty-four male ($n = 20$) and female ($n = 4$) high school students, enrolled in surf PE classes at two North San Diego County High Schools, participated in this 8-week study. Ages of participants ranged from 15 to 18 years. All procedures were approved by an institutional review board and participants were informed of the benefits and risks of the investigation before signing an institutionally approved informed consent document to participate in the study. In addition, parental signed consent was also obtained. The study conforms to the Code of Ethics of the World Medical Association (approved by the ethics advisory board of Swansea University) and required players to provide informed consent before participation.

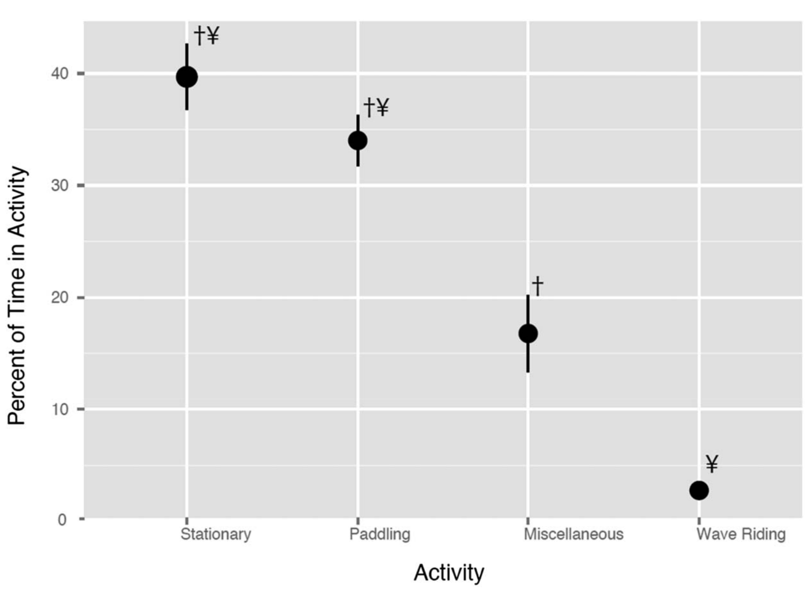


**Figure 1.** Proportion time spent in surfing activity. †Significantly greater than wave riding ($p \leq 0.05$); ¥significantly different than miscellaneous ($p \leq 0.05$). Error bars represent 1 *SE*.

### Procedures

The investigation comprised 2 study protocols. In protocol 1, participants were provided with Polar HR monitors (Polar FT1) at the beginning of each

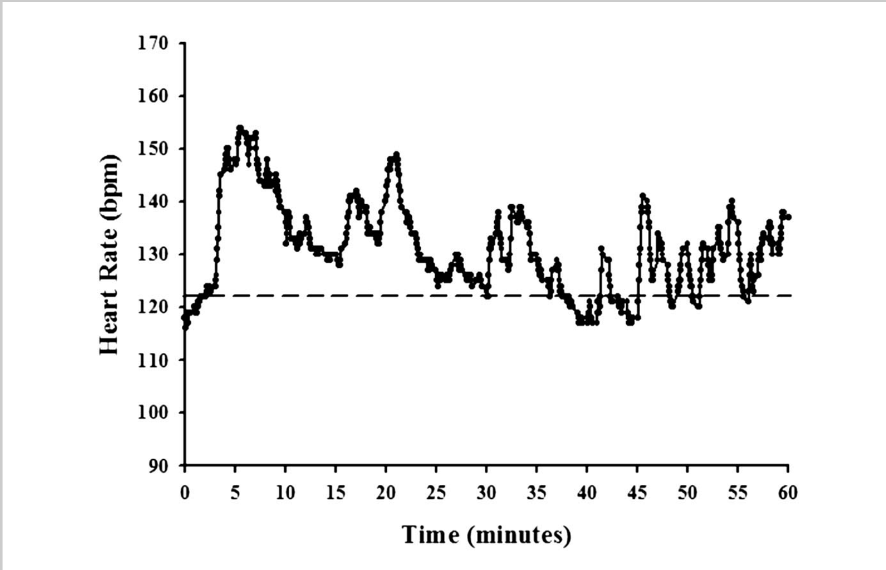


**Figure 2.** Representative heart rate (HR) data during a single surf session. Dashed line at 122 $b\cdot min^{-1}$ represents lower limit of moderate intensity HR range.

class session. Heart rate data and surfing duration were collected daily in all participants. In addition, environmental conditions (wave height and interval, wind direction and speed, and water and air temperatures) were collected daily using information from the National Oceanic and Atmospheric Administration's buoys located offshore. Protocol 2 involved a more detailed analysis of HR and activity in the-water simultaneously during a single session in a subset of students ($n = 11$). Protocol 2 used a different HR monitor (-Polar RCX5) in combination with a video camera (Canon HD).

#### Measurements

*Heart Rate.* In protocol 1, participants were instrumented with a HR transmitter (Polar T31 coded transmitter) placed distal to the xyphoid process and a receiver (Polar FT1) strapped to their wrist. Participants in protocol 2 were similarly instrumented, but a different receiver (Polar RCX5) was used. After instrumentation, HR monitors were turned on and investigators confirmed that HR measurements were being recorded before the participant beginning their surf session. On completion of the surf session for protocol 1, HR monitoring was stopped by the investigator, and average HR, maximum HR, and surf duration were recorded for participants. Heart rate monitors from protocol 2 were also stopped by the investigator but were taken back to the laboratory where HR data were downloaded onto the Polar website (polarpersonaltrainer.com), and the raw HR data were extracted at 5-second intervals.

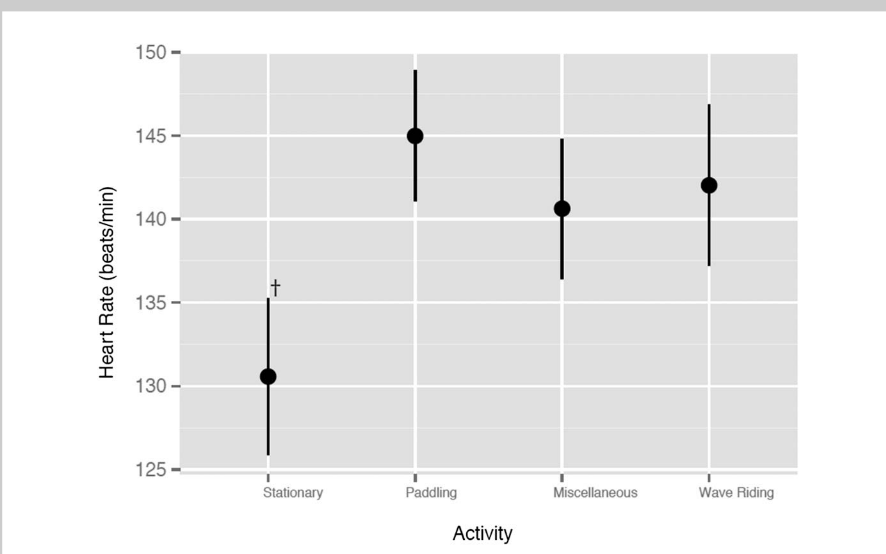


**Figure 3.** Mean heart rate by activity ($n = 11$). †Indicates significantly less than paddling, wave riding, and miscellaneous activities ($p \leq 0.05$). Error bars represent 1 *SE*.

*Activity.* In protocol 2, a subgroup ($n = 11$) of participants volunteered to be filmed during a single surf session to provide insight into the relationship between HR and surfing activity. Before the surf session, a camera (Canon HD) and tripod were set up at an elevated location in close proximity to the area where the surf session took place. Recording of the surf session began simultaneously with the initiation of HR monitoring and ended with completion of the surf session. Footage was analyzed in the laboratory at 5-second intervals, and surf activities were classified as stationary, paddling, wave riding, and miscellaneous. Activities were defined as (a) stationary–lying or sitting on the board with no arm movement, (b) paddling–movement of arms for the purpose of propulsion across the water, (c) wave riding–standing on board while being propelled by a wave, and (d) miscellaneous–all other activities (swimming, wading, and diving under waves).

*Data Analyses.* Activity and HR data from protocol 2 were combined to provide insight into the impact of the activity on HR. Heart rates exported from the Polar website at 5-second intervals were matched with surfing activities that were coded from the surfing footage. These data were then used to calculate average HR per activity and percent time spent in each activity.

### Statistical Analyses

Participant characteristics between protocol 1 and 2 were compared using summary statistics and Student's *t*-test. A Pearson correlation was used to examine the relationship between HR and environmental factors. All data were expressed as mean ± *SD*. Analysis of the differences in HR among activities and time spent in various activities was performed with linear mixed effects models. Participants were entered the model as random effect. As a result of the HR measures being consecutively measured in short intervals, HR was autocorrelated. We included a single-step autoregression lag term (AR1) on the HR series in the model to account for the autocorrelation in HR observations (13). The main effects were evaluated with a likelihood ratio test and individual parameters estimated with a Z-test. Heart rate distributions were using boxplots (14).

## Results

### Participant Characteristics

Participants were similar in age, height, weight, and years of surfing experience in protocols 1 and 2 (Table 1). They were experienced adolescent surfers with body mass indexes between 17 and 32 $kg \cdot m^{-2}$. Most (63%) surfed more than 7 hours per week. Participants in protocol 1 surfed 48% more hours per week, on average, than those in protocol 2.

### Activity

The mean surfing duration for participants in protocol 1 was 61.7 ± 24.0 minutes. Data from protocol 2 demonstrated that surf PE students were active for 54.7 ± 12.5 minutes of the observation periods. Figure 1 represents the percent time spent in stationary, paddling, wave riding, and miscellaneous activities from protocol 2. Percent time spent in paddling and stationary activities was significantly greater than percent time spent wave riding and miscellaneous activities. In addition, miscellaneous activity was significantly greater than wave riding.

### Heart Rate

A representative sample of HR data from a single surf session collected during protocol 2 demonstrates the typical HR response and patterns of variation experienced by the participants (Figure 2). Mean and maximum HRs during protocol 1 surf sessions were 131.1 ± 15.0 and 177.2 ± 17.7 $b \cdot min^{-1}$, respectively. Approximately half of the participants maintained a HR above 140 $b \cdot min^{-1}$ for at least half the session in protocol 1. Seventy-six percent spent over half their session with HRs above 60% of age-predicted maximal HR (122 $b \cdot min^{-1}$), which is consistent with moderate-intensity exercise recommended by the ACSM. Most HRs were above or near this 122 $b \cdot min^{-1}$ threshold in protocol 1. Participants' mean HRs ranged from 128.3 to 147.1 $b \cdot min^{-1}$ and were significantly higher than the ACSM's lower threshold for moderate-intensity exercise ($t = 3.7$; $df = 10$; $p = 0.004$). Duration of sustained HRs above the moderate-intensity threshold averaged 15.9 ± 3.8 minutes in protocol 1. Interestingly, there were no significant correlations between HR and environmental factors.

Instantaneous HRs were related to current activities ($\chi^2 = 60.10$; $df = 3$; $p < 0.001$) (Figure 3). Throughout protocol 2, HRs during paddling, wave riding, and miscellaneous activities were similar and significantly greater by at least 10 $b \cdot min^{-1}$ compared with stationary activity (Figure 3).

## Discussion

The CDC and ACSM currently recommend that adolescents participate in 60 minutes of daily physical activity and suggest that this could be met nationally through PE curriculum. In the current investigation, surf PE students were engaged in the surfing activity for an average of 61.7 ± 1.6 minutes. Stationary (42.7 ± 2.9%) and paddling (36.7 ± 2.4%) activities contributed to the greatest percentage of time for each surf session. This is consistent with the previously published literature reporting that stationary activity comprised 28–42% of time spent surfing in 20–25 years old recreational and professional surfers (11,12,15,16). Interestingly, the time students spent paddling in this study was less than 44–54% that has been previously reported by others (11,12,15,16). Similarly, the percent time spent wave riding during surf PE was less than 4–8%, which has been previously reported in the literature (11,12,15,16). One can speculate that these differences between the percent times that our participants spent in given activities compared with those reported by others may be attributable to several environmental factors. Specifically, much of the previously reported data were collected in competitive or formerly competitive surfers who were performing in real or simulated competitions (11,12,16). Competitive environments such as these likely result in participants spending more time paddling and wave riding in an attempt to increase their scores. In addition, surfing conditions, such as wave height and interval, water and air temperature, and wind speed, likely contribute to these observed differences. This is supported by recent data suggesting that surf conditions influence physiological variables that are closely tied to activity in the water (15). In contrast, we observed no significant correlation between environmental factors and HRs in our subjects participating in surf PE. It is also important to acknowledge that experimental observation may have influenced the surfing activity of students participating in surf PE. We can speculate that the duration of protocol 1 (8 weeks) would have been sufficient to allow students to habituate to the researchers daily presence and likely had a minimal impact on the current findings. Although slight differences may exist between percent time spent in surfing activities from previously published and current data, the more important point is that the overall trends in activities are the same with paddling and stationary activities comprising most time and wave riding plus miscellaneous activities contributing the least.

In addition to duration, the CDC and ACSM recommend that adolescents participate in moderate-intensity aerobic exercise, which is defined by HRs of 60–75% of age-predicted maximal HR. This equates to a HR range of 122–152 $b \cdot min^{-1}$ for surf PE students participating in the current investigation. Therefore, the surf PE students' average HR of 131.1 $\pm$ 0.9 $b \cdot min^{-1}$ falls within the moderate-intensity range. These HRs are slightly less than the 135–146 $b \cdot min^{-1}$ that has been previously reported in the literature for recreational and competitive male surfers (15,16). It is important to acknowledge that surfing is not a continuous aerobic activity (Figure 2); rather, it involves intermittent bursts of exercise, which consist of paddling, wave riding, and miscellaneous activities. These activities are followed by recovery phases. Given this information, it is not surprising that HRs during paddling (145.0 $\pm$ 3.9 $b \cdot min^{-1}$), wave riding (142.0 $\pm$ 4.8 $b \cdot min^{-1}$), and miscellaneous (140.6 $\pm$ 4.2 $b \cdot min^{-1}$) activities were significantly higher than stationary (130.6 $\pm$ 4.7 $b \cdot min^{-1}$) activity in our participants involved in protocol 2 (Figure 3). Further evidence for the intermittent nature of surfing can be derived from the fact that HRs during stationary activity do not return to resting values, which suggests that the stationary interval is short in duration. In addition, maximal HRs of 177.2 $\pm$ 1.0 $b \cdot min^{-1}$ suggest that many of these stationary intervals are followed by activities that elicit HRs that would classify the activity as high intensity. Consistent with our findings are published data suggesting that the high-intensity interval nature of surfing also occurs in recreational and competitive settings (11,15,16). This characterization of surfing as a form of high-intensity interval training (HIIT) is significant given the growing body of literature that suggests that similar land-based HIIT programs can elicit robust physiological training adaptations to metabolism and the cardiovascular system (17,18). For this reason, one can speculate that participation in surf PE may elicit similar metabolic and cardiovascular adaptations in adolescents.

## Practical Applications

The results from the current investigation suggest that physical activity recommendations for cardiovascular health can be achieved when students are provided with activities, such as surfing, that they enjoy and participate in outside of school as part of their curriculum. This is important given that it is well documented that participation in traditional youth sports is waning, whereas participation in nontraditional "action sports," such as surfing, is significantly increasing (15). Given these changes in adolescent interests, it is likely that high school PE programs will need to adopt many of these action sports into their curriculum to engage the growing number of students participating in novel sporting activities. However, limited research characterizing the physiological requirements of these action sports currently exists, and these data will be pivotal if school districts begin offering action sports as a PE option in the future. The findings from the current investigation are the first to provide this type of data and can be used as a resource by high school administrators in coastal school districts in both the United States and abroad to aid in the development of surf PE curriculum.

The findings from this study are also applicable beyond the educational setting in which they were collected. Specifically, surf coaches working with competitive adolescent surfers can use the HR and activity data derived from this study to more effectively develop water and land-based training programs that are specific to surfing. The current findings suggest that youth surf coaches need to acknowledge the importance of paddling in the sport of surfing and develop strength and conditioning programs that enhances the surfer's aerobic capacity during paddling. Upper extremity HIIT should be used as a major component of these strength and conditioning programs because our data clearly demonstrate the intermittent nature of paddling within a given surf session. Finally, our observation that HR remains elevated during stationary phases of surfing suggests that recovery periods between high-intensity intervals should remain short in duration to replicate conditions of a surfing session.

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