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# Stand Up Paddle Surfing – an aerobic workout and balance training

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**Abstract**

Originating from an ancient Hawaiian tradition Stand Up Paddle Surfing (SUP) is a growing pastime and sports activity in which a person stands upright on a surfboard and propels it using a single paddle. During paddling the board constantly is in an unstable condition forcing paddlers to focus on keeping balance and simultaneously propelling the board by paddling. Therefore it is expected that SUP can be a high impact aerobic workout and balance training. A total of 68 subjects performed on-water and SUP ergometer trials, during ergometer trials heart rate (HR) was permanently measured and balance was assessed before and after all trials (ergometer and on-water) using a single leg hop test on a Win Pod electronic baropedometric platform. Results of the balance tests - though for a relatively small number of participants - showed that after ergometer trials a significant improvement in stability occurred whereas it was only significant for the right foot's anteroposterior movement after on-water trials. The result of the exercise-test illustrated that the HR of beginners stays in the aerobic zone which makes SUP suitable for endurance training.


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*Keywords:* SUP ; balance ; heart rate ; Stand Up Paddle Surfing

## 1. Introduction

Stand Up Paddle Surfing (SUP) combines elements of different water sports like surfing, kayaking and rowing. Thus making it a rapidly growing pastime on each kind of waters and for all age groups. During SUP the rider stands on an over-sized surfboard which is between 3m and 5m long and up to 1m wide using a single paddle of about 2m lengths. Using this paddle, the rider is able to control the board in the current or reach fast breaking waves. There is no need of wind or waves as in many other water sports [1,2]. With SUP a new dimension of surfing is introduced which makes it interesting for coasts, rivers or lakes as an alternative for low wind days, as it is possible to paddle under nearly all conditions [3]. Active paddlers of all age groups can achieve improvements very quickly because the boards are wide and stable. A few years ago SUP was referred to as an effective full body workout and metabolic training throughout different social media and internet magazines. Since then it became more and more popular.

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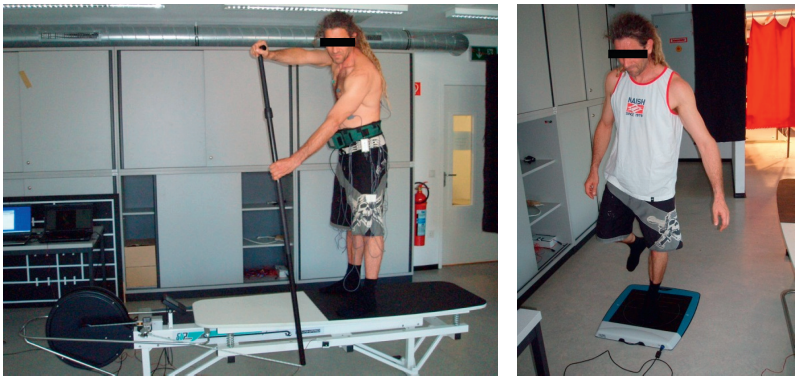

(a) (b)

Fig. 1. subject during (a) physical performance test on a SUP ergometer and (b) single leg hop test on a pressure sensitive measurement platform

The aim of the study was to prove that SUP is a suitable endurance training for amateurs and that it improves the athlete's balance. Thus we hypothesized that (H1) balance improves after a SUP-activity and (H2) heart rate (HR) of SUP-beginners does not exceed anaerobic threshold during SUP.

## 2. Materials and Methods

The tests conducted during this study were done partly in the laboratory (ergometer-trials) and partly in the field (on-water trials). Eight male subjects (age: 31.5 ±8.6 yrs., height: 176.25 ±4.2 cm, weight: 74.13 ±9.88 kg, training per week: 6.375 ±2.45 h) took part in the laboratory tests whereof one subject was experienced in SUP, two were intermediate riders and five beginners. All subjects did a stepwise performance test on a SUP ergometer (Kayak Pro USA LLC, USA)(Fig. 1(a)). Before and after the performance test single leg hop tests were carried out by each subject. The single leg hop test is a function test where the subject hops single legged on a electronic baropedometric platform (Winpod, Medicapteurs France SAS, FRA)(Fig. 1(b)), has to land on the same foot he jumped off with and keep balance - trying to stand as still as possible - for 15 s. During the 15 s balance-phase pressure data is recorded and the movement of the center of pressure (COP) is calculated. The COP movement is used as indicator for the interaction of muscles, ligaments and tendons and their strength [4]. Subjects had to perform five jumps with each foot before and after the performance test - with a 10 min break between performance and balance test.

For the the analysis of the balance performance the average movement of the COP was measured during 15 s of one-legged standing. Ante-posterior movement (forward/backward), and mediolateral movement (left/right) and results for the left and the right foot were evaluated separately. As there are no known performance tests for SUP a typical exercise test for the evaluation of aerobic endurance achievement potential in rowing [5] was adapted. The subjects started at a power output of 6 W for 2 min and were asked to increase their power output by 2 W every 2 min until subjective exhaustion was reached or power could not be increased any more. To avoid premature muscular fatigue subjects had to alternately paddle on their right and left side. During the test HR was measured with a Sigma RC 14.11 running computer (SIGMA-ELEKTRO GmbH, GER).

HR data was compared to the individual maximum HR ($HR_{max}$) and optimum endurance training was assumed to be between 60 and 80% of $HR_{max}$ [6].

For the on-water trials 60 volunteer subjects (36 male, 24 female) were recruited from the spectators of a surf event in 2012. After having given their written informed consent they filled out a personal questionnaire and had to perform two single leg hop tests per leg on the abovementioned measurement device. Then they were equipped with a beginner's SUP board and asked to paddle at a self-chosen pace on the water for 30 min. Subsequently subjects had to perform another two single leg hop tests per leg.

The evaluation of the single leg hop test was based on the average movement in mediolateral and anteroposterior direction during the balance phase. Statistical significance of the data was assessed with a Wilcoxon test at a signifi-

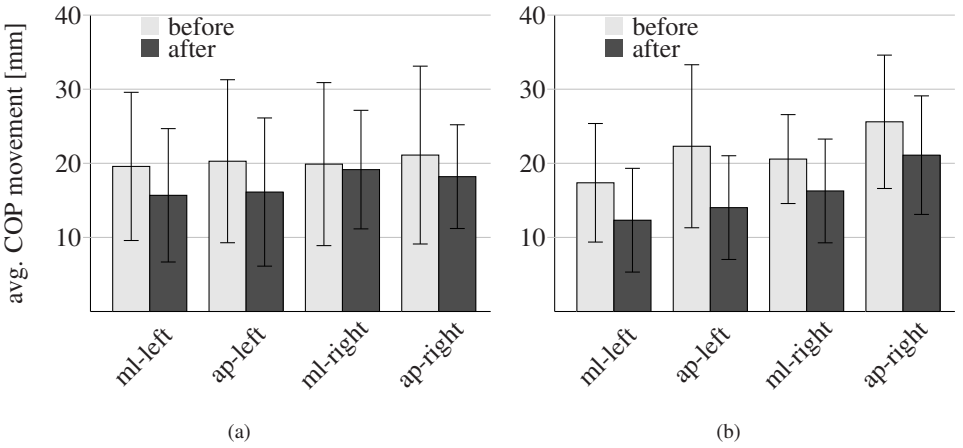


Fig. 2. Overall average COP movement of all subjects during (a) on-water and (b) ergometer trials, light gray: before paddling, dark gray: after paddling; ap-: anteroposterior movement, ml-: mediolateral movement of the left and right foot respectively.

cance level of $\alpha = 5\%$. For the evaluation of the on-water trials the subjects were divided into different age categories (8-17 yrs.: 4 subjects, 18-30 yrs.: 23 subjects, 30-44 yrs.: 9 subjects, 45-58 yrs.: 5 subjects) furthermore test-subjects aged 18-30 yrs. performing more than 9 hours sports per week (12 subjects) and subjects with experience in SUP (intermediates all age groups, 7 subjects) were also considered independent groups.

## 3. Results

Fig. 2 shows the overall results for the average COP movement before and after paddling. The results of the on-water trials are displayed in Fig. 2(a) and show that stability for the left foot in mediolateral direction improved from 19.58±10 mm to 15.68±9 mm and in anteroposterior direction from 20.28±11 mm to 16.12±10 mm. Mediolateral movement of the right foot was rather low (19.89±11 mm) and did not show great changes after paddling (19.15±8mm). The average anteroposterior movement changed from 21.11±12 mm to 18.20±7 mm.

For the ergometer trials (Fig. 2(b)) similar results with even better improvements in stability can be observed. For the left foot average mediolateral movements decreased from 17.37± 8 mm to 12.32±7 mm. The improvements of the anteroposterior movement were even bigger (from 22.3±11 mm to 14.02±7 mm). The right foot however did not show as much improvement (from 20.57±6 mm to 16.27±7 mm). The right foot's anteroposterior movement showed the largest mean amplitude and changed from 25.67±9 mm before paddling to 21.17±8 mm after paddling. Splitting the results of the on-water trials into the aforementioned age-groups yields and interesting result (Fig. 3). For both movement directions (Fig. 3(a): mediolateral, Fig. 3(b): anteroposterior) the age group of the 8-17 year-olds show a considerable decrease of COP movement after the paddling exercise. Also 45-58 year-olds and experienced SUP riders (intermediates) show clear improvements. However for all other groups it must be stated that improvements are only to be observed in one direction or not at all.

At the age 8-17 the improvement was the highest. The mediolateral movement was 21±8 mm before and decreased to 13±8 mm after paddling. The balance for ages 18-30 and 30-44 changed for the worse from 16±7 mm to 17±7 mm and 20±8 mm to 22±9 mm respectively. The 18-30 aged test persons who perform 9 h of sports per week (s18-30) improved from of 20±6.5 mm to 18±5 mm. The 45-58 year old subjects improved also (from 21±9 mm to 18±9 mm). It is noticeable, that the intermediates had the largest COP movements but improved from 31±7 mm to 24.5±5 mm.

For the anteroposterior movement the intermediate riders showed the biggest improvements (from 26±6 mm to 15.5±6 mm). All beginner age classes had an improvement except the age group of 30-44 who reached nearly stable mean values of 22 mm vs. 22.5 mm. Subjects aged 18-30 yrs. had the best beginning balance. They started at 17.5±7 mm before paddling and improved to and 15.5±7 mm. The group of the 45-58 year old subjects had the best balance after paddling (14.5±8 mm).

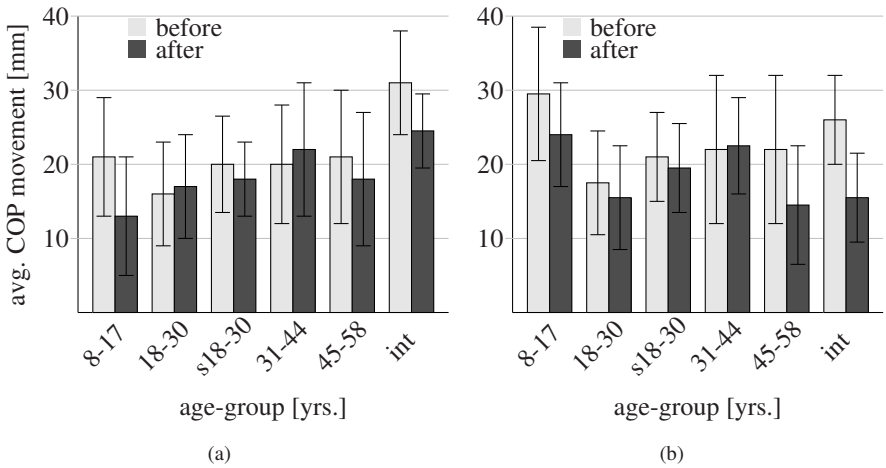


Fig. 3. Overall average COP movement of on-water trials (a) mediolateral movement (b) antero-posterior movement, for different age-groups. (s18-30: 18 to 30 year olds performing more than 9h sports/week, int: intermediate experience in SUP), light gray: before paddling, dark gray: after paddling.

The assessed HR for all subjects during the stepwise ergometer trials is displayed in Fig. 4. It is noticeable that HR of all subjects rose nearly linearly with increased power over time. Five of the eight subjects were not able to exceed anaerobic threshold. They stopped the exercise test at a HR of about 145 bpm and a power of 24 W before reaching subjective exhaustion.

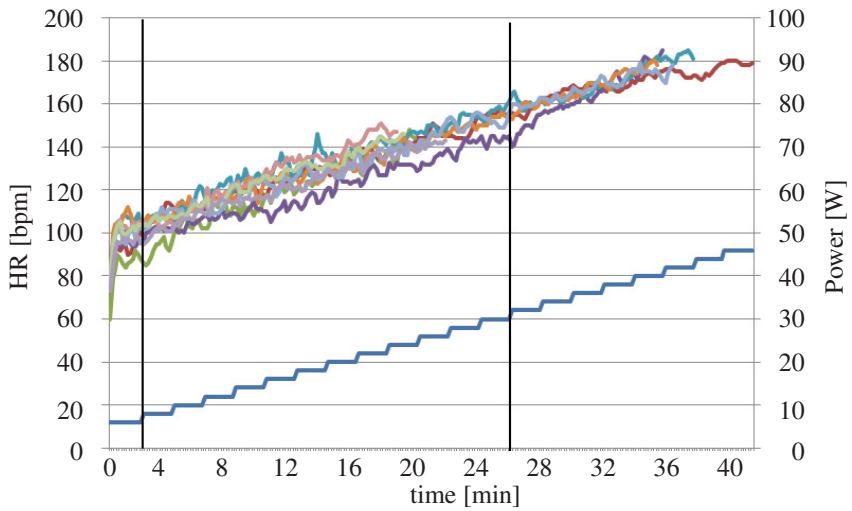


Fig. 4. Heartrate (HR) [bpm] and power [W] plotted over time of all subjects in the ergometer test. The dark gray line in the lower half of the figure represents the power steps, the coloured plots represent the HR-distribution of every single subject, vertical lines signify the start after the warmup-phase and the approximative power level where subjects reached 80% of $HR_{max}$ respectively.

## 4. Discussion and Conclusion

The results of the Wilcoxon test showed a significant improvement for the balance stability for the laboratory tests in the average mediolateral and anteroposterior movement for both feet. The ergometer tests have been accomplished

under constant parameters. Nonetheless the standard deviation was rather high. The improvements for the left foot were slightly higher than for the right foot.
It was expected, that the subjects' dominant foot would show better balance results before paddling as muscular control usually is better in the dominant leg. Also subjects reported that the single leg hop was more difficult with their non-dominant leg.
The overall results of the on-water showed improvement (cf. Fig. 2), but were not coherent for the age groups examined (cf. Fig. 3). Some age groups even showed deterioration of balance. However standard deviations are high and the number of tested subjects is small. The clear improvement of the age group 8-17 years was expected as it is well-known that children are able to quickly adapt to coordinative challenges and to improve coordination. Nonetheless also in the oldest group (44-58 years) an improvement and activation of balance was detectable.

Comparing the on-water results to the ergometer results it can be observed that under controlled conditions with stable parameters balance improved for all tested situations.

The balance measurements confirm the assumption that SUP enhances the balance. The results illustrated an overall improvement of the balance, especially for the ergometer tests, which all were statistically significant. This leads to the fact that SUP is qualified for rehabilitation exercises and also as a falling prevention especially for the age group 50 plus.

Thus H1 can be verified for ergometer testing, and for the overall results of the on-water trials, but can not be verified for all age groups.

After analysis of all data of the stepwise exercise test, it was obvious that the heart frequencies of all test persons rose nearly linearly. Five of the eight test persons stopped the test before they reached their individual anaerobic threshold without being subjectively exhausted. They stopped, because they had to concentrate on keeping balance on the unstable underground (i.e. board) and therefore could not put enough effort in the paddling to maintain the demanded power output. The unstable feeling increases with increasing effort of paddling. Because of the instability of the board it is very difficult to hold balance and paddle with sufficient effort to reach the required wattage.

The three subjects whose HR exceeded anaerobic threshold were experienced paddlers. The beginners (i.e. those who aborted the test before subjective exhaustion) reached a HR of 60-80% of $HR_{max}$ which is considered ideal for endurance training. Besides that, beginners often do not want to paddle as fast as they could to avoid falling of the board, so with a moderate intensity an optimal endurance workout can be achieved. Thus H2 (HR of SUP-beginners does not exceed anaerobic threshold during SUP) was verified for the population in this study. However to find generally valid evidence analysis of a larger population is required.
Summing up the results it can be stated that given the low risk of injury SUP could prove to be a good workout and balance training for untrained, overweight or even elderly people.

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