ABSTRACT

An analysis of two stand-up paddleboard ‘distance’ events was undertaken to investigate any change in their participation, racing behaviour and whether such events should be approached differently by practitioners. The completion time paddler-to-paddler gap was investigated as a means of assessing the performances in two flatwater distance events from 2013-2017. The level of participation at these events had not noticeably changed. An analysis indicated that both events did not significantly change in their completion time paddler-to-paddler range from year to year when looking at three sub groups ($p>0.05$) and did not differ significantly in behaviour when normalised against each other ($p>0.05$). Post-hoc tests then revealed that the paddler time gaps at an event held in 2015 were significantly different when compared to all of the other years it had taken place ($p<0.05$). The use of a performance intensity chart indicated that there was different finishing paddler-to-paddler gap behaviour between the two events. Ultimately, it is proposed that athletes and coaches should be aware that two events with the same generic classification of being designated a ‘distance event’ may warrant different training methodologies and tactical decision-making.

KEYWORDS: completion time, performance, racing, stand-up paddleboarding

INTRODUCTION

Stand-up paddle boarding (SUP) is a relatively recent competitive pastime and a recreational water sports activity that has been increasing in popularity (1). Whilst SUP has contentious origins, it comprises elements and skills similar to those from traditional surfing, outrigger canoeing and inland canoeing (2). SUP requires a paddler who is positioned standing up on a board to then provide forward motion through use of a long, single bladed paddle. To maintain a straight course, a SUP board typically has a single fin positioned underneath the board and towards its tail. The athlete periodically switches sides with their paddle to assist in this directional control and to provide overall propulsion.

It is not definitive when SUP racing was formally introduced to the UK but anecdotal reports suggest it was circa 2006-08 (https://standuppaddlemag.co.uk/2017/03/13/history-lesson-uk-stand-up-paddle-boarding-10-years-on/). During 2016, it was announced that surfing will make its debut at the 2020 Olympic Games. The governing body for surfing also encompasses the SUP discipline, therefore it is not inconceivable that it could be included in the Olympic Games in the future. As a result, research into this newer competitive sport is timely.

SUP has several competitive disciplines and these typically comprise long distance races, technical races (that involve negotiating around a series of buoys) and surfing contests (whereby points are awarded to athletes for performing techniques and manoeuvres whilst surfing a wave). Both distance and technical races can take place on either calm flatwater locations (such as rivers or lakes) or open water (such as the sea or

ocean). The courses generally utilise no lanes or boundaries which leaves the paddlers free to position themselves relative to each other as they see fit. However, this freedom also creates the opportunity for *drafting*. Drafting is the practise of one or more paddlers obtaining shelter by positioning themselves directly behind or to the side of another paddler. A group of paddlers undertaking this practise is informally referred to as a 'train'. Anecdotally, the sheltered paddler requires less energy to maintain the same speed as the paddler in front due to reductions in their hydrodynamic drag. To the best of our knowledge, no study to date has investigated this behaviour.

As the racing disciplines have developed, so has the equipment that is used to best facilitate them. However, SUP has received scant peer-reviewed research to date. The majority of such studies are predominantly credited to one author (1, 3, 4, 5, 6). These studies stated that SUP is a globally performed physical activity but with a high concentration in Australia (6). In addition, it proposed that SUP athletes possess a high level of fitness, strength and balance (3) and that long term participation appeared to be associated with improvements in body composition, aerobic fitness and trunk muscle endurance (4).

SUP's competitive participation could be considered in a state of early development. Only one study to date has performed any performance analysis of SUP-based racing (5). This study investigated the pacing, physiological intensity and paddling trajectory of athletes undertaking a single open water distance race. The finding of this study suggested that the sport involved a high aerobic demand involving near-maximal heart rates over the full duration of the race. It was also noted that the

path of paddlers deviated from each other slightly, thereby suggesting an influence of tactical decision-making that could influence the race results. However, the sample size in this single study was relatively small and only concerned ten paddlers spread across both genders. As a result, it only provided the starting point of the performance analysis of the physiological and tactical requirements of SUP.

This study builds upon previous research by providing further investigation into SUP racing. The first aim of this study was to investigate the development and behaviour of two different events held over a longer period of time than the single event case-study used in the Schram paper (5). The second aim was to ascertain whether two races designated as ‘distance events’ exhibited different racing behaviour. Knowing how such events have developed could provide participants and coaches guidance into developing appropriate training strategies for this sport.

METHODS

Before addressing the research aims, an informal survey took place to identify any SUP distance events in the UK that had been run over the same course and for at least three years. Two events fulfilled this criteria and they formed the basis of this papers analysis. They were the 16km ‘Battle of the Thames’ (BOTT) event from 2014-2017 and the 12.8km ‘Head of the Dart’ (HOD) event from 2013-17.

Subjects

This study investigated the male, 14ft long SUP board race class at these two events. Other race categories such as the female classes or different board lengths and designs

were deemed to be too few in number to be a reliable source for analysis over this period of time. The results for both events were sourced directly from the public domain. The HOD results were sourced online (www.headofthedart.wordpress.com), as were the BOTT (www.windsurfer.co.uk/SUP_BattleOfTheThames.htm). Both events took place on rivers. Both events saw athlete times recorded using stopwatches. The statistical analysis in this study was performed using Microsoft Excel software (Redmond, US). The study received institutional ethics approval.

Statistical Analyses

To satisfy the first and second aims of this paper, the trends in paddler-to-paddler finishing gaps formed the basis of the analysis. These finishing gaps may be representative of actions and tactics that took place during an event as a whole, those partially within it or indicated those that took place near its end. Any changes in these finishing gaps may also have been indicative of the sports development or changes in its physiological and tactical philosophies. The following statistical analysis took place:

SUP Event Participation. The sports development was assessed by investigating the number of competing paddlers at the BOTT and HOD events over the 2013-17 time-period and the resulting progression or change in the paddlers completion time.

Paddler to Paddler Analysis. The BOTT and HOD events racing behaviour was investigated through use of an ANOVA calculation of the paddler-to-paddler completion time gaps from year to year within five sub-groups. These five sub-groups comprise paddlers who completed the event within a <5 second, 5-10 second, 10-30

second, 30-60 second and >60 second gap from each other. Post-hoc student unpaired *t*-tests were then undertaken to compare all years against each other for both the BOTT and the HOD events.

Event to Event Comparison. A comparison of the BOTT and HOD events were directly compared to ascertain if they exhibit different behaviour from each other. Student unpaired *t*-tests of the HOD and the BOTT were used. Two forms of normalisation used for this purpose were:

i. *A normalisation of the BOTT and the HOD on a second's per km basis.* This was calculated as the range (in seconds) between 1^{st}-5^{th}, 1^{st}-10^{th} and 1^{st}-20^{th} places divided by the proposed race distance of 12.8km (HOD) or 16km (BOTT). These groups suggested race field strength and development.

ii. *The paddle-to-paddler gap as a percentage of their completion time.* It could be suggested that the increased distance provoked larger gaps between its paddlers due to the extra duration required to complete the event. As a result, this normalisation was achieved by taking the paddler-to-paddler time gap and converting it as a percentage of each paddler's individual completion time.

All means are reported with their respective standard deviations. The level of statistical significance for both the ANOVA and the *t*-tests was defined as <0.05.

The Performance Intensity Chart. To further illustrate the behaviour within the two events, the use of a novel qualitative/quantitative mixed-method technique known as the 'performance intensity chart' (PIC) was proposed. The PIC utilises quantitative information and illustrates this qualitatively using colour intensity. This expression of colour illustrates the 'personality' or characteristics of a selected sporting event. It does this by allocating a colour to a pre-determined paddler-to-paddler finishing time gap. The closer the finishing paddler-to-paddler gap, the more intense the colour that is allocated to it. Once the time gaps between all athletes are designated, an overall chart of the event is constructed. Whilst these gaps can be analysed statistically, the PIC chart supplements these by being able to compare races visually. The reliability of the PIC is based directly on the reliability of the timing method used to record an athlete within a sporting event. The validity of utilising colour intensity as a means to infer importance or suggestion has been utilised in several diverse academic fields. These have included stress analysis in *engineering* (7), food labelling in *food technology* (8), fluid dynamics in *sports engineering* (9), magnetic resonance imaging in *medical science* (10) and digital image processing in *geography* (11). The colour intensity itself is arbitrary in its colour hue or value allocation. In the case of this paper, the colour intensity progression followed those examples discussed in the introduction so therefore transitioned from white through to red. The colour intensity banding was defined as a paddler-to-paddler time gap using dark red (<5 second finishing gap), bright red (5-10 second finishing gap), orange (10-30 second finishing gap), yellow (30-60 second finishing gap) and white (>60 second finishing gap).

Event to event normalisation could be made more directly by illustrating the gaps using a percentage of the athletes individual total event time (rather than the raw gap time in seconds). However, it was felt that the event completion time gaps suggested actionable intelligence for athletes and coaches whereas a percentage did not allow this so clearly.

RESULTS

SUP Event Participation

The mean number of entrants of competitors in the HOD from 2014-2017 was 33.3+/-8 and its coefficient of variation (CV) was 23%. The number of competitors in the BOTT from 2013-2017 was 25.2+/-3and its CV was 11.7%. The trend of participation is illustrated in figure 1.

[Figure 1 near here]

It is felt that two outliers exist in this participation data. They are the HOD in 2015 and the BOTT in 2017. With the removal of these outliers, the HOD CV was 4.7% and the BOTT was 2.2%

Paddler-to-Paddler Analysis

A summary of the completion time information for the HOD and the BOTT are shown in tables 1 and 2.

[Table 1/2 near here]

The paddler-to-paddler gap was then expressed as a percentage of the paddler (behind) event completion time. A single factor ANOVA was calculated for each event separately between its participation years of its 1^{st}-5^{th}, 1^{st}-10^{th} and 1^{st}-20^{th} groups of paddlers. The results are shown in table 3.

[Table 3 near here]

In table 3, the BOTT paddler-to-paddler completion time gaps (when evaluating the 1^{st}-5^{th} and the 1^{st}-10^{th} ranges) were not considered significant from each other over the entire 2013-2017 period. The HOD paddler-to-paddler finishing gaps were not considered significant from each other generally over their 2014-2017 period. However, the exception to this was in the 1^{st}-20^{th} completion time gap sample. From this, the post-hoc *t*-tests did reveal some specific year to year statistical significance. For the HOD the percentage reduction to the paddler in front was significantly different for the 1^{st}-20^{th} group from 2014 vs 2015 (p=0.03), 2015 vs 2016 (p=0.01) and 2015 vs 2017 (p=0.04). Whilst this does not indicate a trend and is isolated to the largest sub-group, it does suggest that the 2015 event in particular was a consistent anomaly compared to other years. For the BOTT, there was no consistent trend and statistical significance was only obtained for 2014 vs 2017 in the 1^{st}-20^{th} group (p>0.05).

Normalised Comparison of the HOD and BOTT

The *t*-tests of the HOD and the BOTT paddler-to-paddler gap range when normalised on a second's per km basis revealed no statistical significance between the 1^{st}-5^{th}, 1^{st}-10^{th} or 1^{st}-20^{th} place sub-groups ($p>0.2$).

Likewise, when the paddler-to-paddler gap (expressed as a percentage of their completion time) was calculated, the *t*-tests of the HOD and the BOTT paddler-to-paddler gap range when normalised on a second's per km basis revealed no statistical significance between the 1^{st}-5^{th}, 1^{st}-10^{th} or 1^{st}-20^{th} place sub-groups ($p>0.08$).

Performance Intensity Chart

The PIC for the HOD and the BOTT is shown in figure 2.

[Figure 2 near here]

The BOTT PIC illustrates more colour intensity than the HOD by virtue of larger blocks of colour other than white. This is particularly noticeable in the BOTT that has a greater visible lack of colour intensity towards the rear half of the race field in each year than the HOD. This diagram is supported with the statistics that the HOD had a greater percentage of paddlers closer together in 4 of the 5 completion time sub groups. The BOTT is 25% longer in race distance than the HOD. However, the BOTT also saw greater reduction in paddler-to-paddler completion time in four of the five event completion time sub groups. These percentage reductions were 5% (<5 second), 44% (5-10 second), 57% (10-30 second) and 49% (30-60 seconds). However, the

percentage of paddler-to-paddler completion time of >60 seconds was a 70% increase at the BOTT when compared to the HOD.

When combining all of the athletes performances for each event into one pool, the percentage of paddlers with each paddler-to-paddler gap for the HOD were 6% (<5 seconds), 9% (5-10 seconds) and 28% (10-30 seconds). The remaining 57% had a paddler-to-paddler finishing gap greater than 30 seconds. For the BOTT these same percentage splits were 6% (<5 seconds), 3% (5-10 seconds) and 13% (10-30 seconds). The remaining 78% had a paddler-to-paddler finishing gap greater than 30 seconds.

The PIC does not provide a clear visual indication that there was change or alteration in behaviour from year to year at either event. This was supported by the ANOVA results provided earlier in this paper. However, it does suggest that the shorter length of the HOD event created smaller finishing gaps than the longer duration BOTT.

DISCUSSION

Development of the SUP Events

The first aim of this study was to assess the development and behaviour of two different events held over a longer period of time than previous studies has investigated. Whilst the CV of the HOD participation from 2013-2017 was nearly twice that of the BOTT, both events data has been skewed by an uncharacteristic dip in participation in one of the years it has been held. The HOD saw an uncharacteristic dip in participation in 2015. Anecdotal feedback from the HOD organiser suggested this was due to severe weather taking place that year. It was interesting to note that the post-hoc significance

tests in this study revealed that the 2015 event saw significant different time gaps (as a percentage of the participant's completion time) from that of the other years when evaluating the largest sub-group. This would reinforce the anecdote that the 2015 event saw challenging weather and this possibly impacted on its participant's individual performances. However, the fact that the smaller sub groups did not produce any statistical significance may suggest that as a result, the slower paddlers are more impacted by challenging paddling conditions than the faster ones. There was no anecdotal explanation available for the BOTT dip in participation in 2017. With the removals of these outliers, the CV's of the participation numbers dropped to very low levels. Therefore, it is felt that generally speaking, the participation level is steady and neither event is increasing or decreasing in participation when assessing the 4-5 year span. Subsequently this neutral trend provides no basis for any major evolution in racing behaviour due to changes in participation volume.

SUP Distance Events Training Strategies.

The second aim of this paper was to ascertain whether two events characterised as 'distance events' may require different racing strategies. It has been suggested within non-academic peer reviewed publications (and event photography) that the use of 'draft trains' are evident within SUP distance racing. SUP drafting could be considered a similar concept as swimmers slipstreaming each other when in a group when moving through water. In this case, the ability to shelter behind another has been demonstrated to reduce an athlete's oxygen uptake, heart rate, blood lactate, and their perceived exertion (12). As a result, a SUP paddler could potentially benefit greatly by employing similar tactics. It was hoped that the data in this study could infer this behaviour by

indicating a marked decrease in the finishing gaps at both races from year to year as this practise became more widespread. However, the number of paddlers competing in both events has not increased (thereby not providing more opportunity) and the ANOVA of paddler-to-paddler completion time did not demonstrate any significant changes in either the BOTT or the HOD over the assessed durations. As a result, the assessment of completion time alone in this study cannot suggest whether the use of draft trains has become more or less prevalent.

Coaches and athletes should be mindful that some of the small athlete-to-athlete time gaps recorded at the finish line could be reduced or removed entirely with the ability to perform a ‘sprint finish’ at its end. The results in this study showed that 43% of paddlers at the HOD had a paddler-to-paddler finishing gap of 30 seconds or less and that the fastest paddlers completed the race with an average velocity of 9-10kph. At the BOTT this was 22%. The paddler-to-paddler sub-groups utilised for the PIC in this study could be used to illustrate the effectiveness of a sprint finish. For example, if two paddlers were moving at 9kph and were separated by a gap of five seconds, if the paddler behind then increased their speed by 1kph, it would take 45 seconds to remove this gap. Likewise, if this gap was 30 seconds, it would then take 4.5 minutes to close this gap. As a result, it could be argued that such durations would not benefit from a sprint finish such as those witnessed in other sports like track athletics or cycling. In addition the hydrodynamic drag acting on watercraft is non-linear and rises exponentially with increases in velocity (13). This means that any acceleration of the board is going to require an exponential increase in the paddlers effort. However, there is no research to date that investigates the additional increases in hydrodynamic drag or

energy that is needed as a board accelerates. Nonetheless, it seems likely that the concept of a short duration, high power output sprint finish is not a typical occurrence in these two SUP races. As a result, the gaps between paddlers in these races could be better addressed earlier in the race whereby there is more flexibility with both pursuit velocity and applied exercise intensity.

When both events paddler-to-paddler gaps were normalised against each other on a second's per km basis or as a percentage of their completion time, neither event proved significantly different in behaviour to the other. This suggests that the event racing distance (rather than the specific event itself) is currently the main difference between them. Despite the unlikely similarity of environmental conditions at the events, this finding would be in line with other endurance sports. However, it is conceded that any normalisation of the gaps in this study do not account for any use of draft trains. This practise could distort the statistical analysis in this study by allowing some paddlers to finish closer to others then if they had merely paddled alone.

The proposal of the PIC proved useful in being able to provide a visual 'snapshot' of a race in the same way that such colour coding was utilised in other academic fields. Its use of colour intensity instantly suggested how competitive or contentious a SUP race had been. In the case of this paper, it indicated that the HOD possessed much closer paddler-to-paddler gaps at the finish. Whilst this might seem obvious when considering that the BOTT is 25% longer in distance than the HOD, it does highlight that the training that athletes may undertake for these two similarly titled 'distance' races may actually need to be different. The study by Schram et al. (5) did

propose that a distance race is generally an aerobic, maximum effort endeavour. However, to develop this finding, any within-race variation in board speed and its subsequent physiological energy requirements should now be investigated further.

Whilst it is recommended that the PIC diagram is supported with traditional statistical methods, its adoption may prove useful when the event completion time is evaluated to suggest an events competitiveness or quality. Such examples could involve sports such as track athletics or swimming. In addition, whilst arbitrarily selected in this study, the coloured banding thresholds of the PIC could be formally aligned to physiological markers such as the different energetic systems or fuel sources utilised by an athlete.

The optimisation of equipment selection could positively influence a paddler's outcome in these events. The SUP stroke index (13) could be repurposed to optimise paddlers and their equipment to then apply a cycling-esque team approach. This would conserve an athlete's energy requirements by sharing the workload or sacrificing athletes in turn to reduce or remove paddler-to-paddler time gaps within a race. The use of GPS trackers or proximity sensors on all participants could help investigate the impact of this drafting and pacing behaviour. A limited use of GPS technology has already been used to monitor the tracking of athletes in a SUP event (5). However, the understanding of SUP's racing dynamics would be enhanced further by performing GPS-based data collection for every athlete in a race. This technology would need to possess the accuracy and precision to reliably detect a distance of one board positioned directly behind another. An evaluation of more events and of those held over different

time periods, distances and environmental conditions would be beneficial to further understand the impact of draft trains and pacing changes.

Practical Applications

This study builds on previous research by investigating the behaviour of two well-attended SUP events over a longer time period than previously considered. Its aims were to investigate the participation and performance of SUP ‘distance’ events. The participation levels over the limited period of time did not provide any noticeable positive or negative trends. Subsequently, this neutral trend provides no basis for any major evolution in racing behaviour purely due to changes in participation volume. Whilst the racing behaviour of the two events was not seen to significantly change, it is proposed that the key behavioural differentiator between them appeared to be centred on their race distance. Whilst this study does not contradict previous claims that SUP requires a high aerobic capacity, it does propose that athletes and coaches should be aware that the two events that were designated as a ‘distance’ event, may have consistently warranted different training approaches and tactics. Either way, when considering the type of events investigated in this study, it is proposed that athletes should not rely on a short duration, high intensity sprint finish near its end. These types of finishes were proportionally few in number. The length of time required to remove paddler-to-paddler gaps could potentially require durations requiring minutes rather than a few seconds. As a result, any gaps between athletes would be better addressed earlier in the event when there is more flexibility in the time and physiological effort needed.

Finally, this study also provides athletes and coaches with a novel performance analysis technique that they can apply to assess the behaviour of any SUP race that they may wish to assess.

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