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VALIDATION OF A 5K AGE AND WEIGHT RUN HANDICAP MODEL

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ABSTRACT

Vanderburgh PM, Laubach LL. Validation of a 5K Age and Weight Run Handicap Model. ***JEP**online* 2006;9(3):33-40. Though increasing age and body weight (BW) have been widely known to be associated with slower distance run times, the common convention in 5K road races is to categorize competitors by age and, sometimes, BW. This has the disadvantage of assigning only small numbers of competitors to age categories and giving advantage to runners close to the minimum age or BW values allowable. Using recent advances in the modeling of distance run performance by BW combined with empirical evidence quantifying the independent effect of age on cardiovascular endurance, we previously published the derivation of the 5K Handicap (5KH), an age and BW handicap model for the 5K road race. With the inputs of age, BW and actual run time, the 5KH computes an adjusted run time which can be used to compare runners of different age and BW within the same gender. In this study, we field tested the 5KH in two local races with 275 men and 126 women. Results suggest that the 5KH eliminates the age and BW bias, and may provide more incentive for older and heavier runners to compete. Furthermore, the BW bias in the 5K tended to be lower for women than for men. The first scientifically-based age and BW graded system, the 5KH appears valid for both genders and may have application for other race distances and fitness testing environments.

Key Words: Age, Body Weight, Distance Running, Road Racing, Handicap

INTRODUCTION

While there are many factors that contribute to distance running performance, the notion that increasing age and body weight (BW) contribute to slower times is widely accepted. Nearly all such races have age categories and, in some cases, BW divisions. The primary limitation of the age categories, (e.g., 50-54, 55-59, 60-64, etc.), is that there are often very few competitors in the older categories, and sometimes fewer runners than awards. When BW divisions are used, there are typically only one or two heavier BW divisions added, such that runners above the minimum BW (the least BW allowed to be in that division) can compete against each other. The divisions (www.clydesdale.org), named "Clydesdale" for men and "Fillies" for women, are broken down as Clydesdale A: 200–225 lbs (90.7– 02.0 kg), Clydesdale B: 225^{+}lbs (102^{+}kg), and Fillies: 150^{+}lbs (68.0^{+}kg). The limitations of an age and/or BW category system could be mitigated by using a handicapping system that more precisely handicaps age and BW as continuous variables. Using recent advances in the modeling of distance run performance by BW and the empirical evidence quantifying the independent effect of age on cardiovascular endurance, we previously developed the 5K Handicap (5KH), a formula that adjusts one's actual 5K run time by BW and age (1). Because the focus of our previous work was the derivation of the 5K, the focus of the present investigation was to apply the model to a large sample of men and women runners to evaluate the degree to which it eliminated BW and age bias.

Although the details of the 5KH are discussed elsewhere (1) the first step in developing the 5KH was to model the physiological effect of age on distance running performance. This was based on two key relationships: age vs. maximal oxygen uptake (VO_{2max}) for men and women and VO_{2max} vs. distance run time. Using large sample sizes, Jackson and colleagues (2,3) quantified the change in VO_{2max} due to age, independent of percent body fat and self-reported physical activity, as 0.25 and 0.26 ml O_2/kg/year for women and men, respectively. Combining these findings with an equation developed by Nevill (4), which links 5K run speed with VO_{2max}, we calculated the effects of age on changes in 5K run time (1).

The second step was to model the physiological effect of BW on distance running performance. Combining Nevill's equation (4), which also included BW, as well as findings of Astrand and Rodahl (5) that VO_{2max} should scale by BW raised to 2/3 power, led to the conclusion that distance run time should be proportional to BW raised to the 1/3 power (1). This relationship, which has since been supported empirically (6,7), means that if a runner were a scale model of him/herself but 10 percent heavier (the same as multiplying by 1.10), then his/her run time would increase by $(1.10)^{1/3}$ or 1.0323 (an increase of 3.23%). While this relative adjustment may appear to be insignificant, this change translates to nearly 39 seconds extra for a person who runs a 1200 sec (20:00) 5K, which could clearly alter the order of finish.

The effects of age and BW on run time were then combined into gender specific equations as previously reported (1). With inputs of actual 5K run time (RT), age, and BW, the equation yields an adjusted run time (RTadj) which, in turn, can be used to compare runners of different age and BW. However, since the underlying theory applies to physically mature adults the 5KH model imposes both age and BW minimums of 25 years and 50 kg for women and 65 kg for men. These limits are based upon the average age (25 years) for elite male and female 5K runners (International Association of Athletics Federation, www.iaaf.org, Dec 2005), and the average BW of world class runners used in published research studies with samples of at least 25 subjects (8,9). Thus, RTadj for subjects younger than 25 years of age or lighter than 50 kg or 65 kg for males and females respectively, is derived using age and BW minimums described above.

Table 1 illustrates the effect of the 5KH on four hypothetical runners. Runner A, who is younger, lighter, and faster than Runner B, actually has a slower RTadj because of the handicap linked to the documented effects of age and BW. Fig. 1 shows 5KH instructions, as well as a link for both a web-based calculator and a race director spreadsheet file from which to calculate multiple RTadj times.

Table 1. The 5K Handicap with Four Hypothetical Runners.

Runner	*Gender*	*RT (sec)*	*Age (yr)*	*BW (kg)*	*RTadj (sec)*
A	M	1200	27	68.03	1170
B	M	1332	43	88.89	1096
C	F	1404	28	54.88	1339
D	F	1615	39	78.91	1277

RT: actual 5K run time; BW: body weight
RTadj: The 5K Handicap adjusted run time based on age and body weigh

The 5K Handicap in Brief

1. ***The 5K Handicap web calculator can be found at: http://academic.udayton.edu/PaulVanderburgh/Flyer%20Handicap.htm***
2. ***Four pieces of data are needed: gender, age, body weight (lbs) and actual 5K run time. The web calculator produces the adjusted run time which can be compared with that of other runners of the same gender but of different ages and body weights. The website provides links to actual 5K Handicap results for comparison purposes.***
3. ***For the purpose of calculating the adjusted run time and:***
    a. ***For ages under 25, the web calculator will automatically use 25 as the age***
    b. ***For body weights under 110 lbs and 143 lbs for women and men, respectively, the web calculator will automatically use these values for body weight***
4. ***Race directors who need to calculate large numbers of 5K Handicap scores may download an Excel spreadsheet from this website.***

Figure 1. The 5K Handicap Rules and Website

METHODS

Subjects

To validate the 5KH on runners in actual events we applied the 5KH to 275 men and 126 women competing in two regional 5K races in Southwest Ohio. Study participants were runners who volunteered to participate not only in the race but the 5KH as well. As such, they provided written consent for both and received a briefing on the procedures for the 5KH. They were recruited via flyers, race website, and/or exhibit booth at packet pick-up (two days prior) and the race day registration site. Subject descriptive statistics are shown in Table 2.

Table 2. Validation Study Participants.

Conditions	*Men (N=275)*	*Women (N=126)*
Age	42.7 ± 13.7	38.8 ±.13.0
Body Weight (kg)	82.6 ± 14.3	62.3 ± 8.9
5K Run Time (sec)	1476.8 ± 266.0	1680.1 ± 206.2

Procedures

Participants reported to either a packet pick-up site two days before the race, or a weigh-in station on race day where they volunteered to participate in the 5KH. In either case, subjects were weighed on one of three calibrated digital scales and BW was recorded to the nearest ½ kg. Due to time constraints and weigh-in capacity, we measured each subject only once in either their street clothes or race attire. For those in street clothes, a 1.5 kg adjustment was made to approximate their BW with race attire. Both races were on flat courses with race temperatures varying between 14 and 18°C.

Statistical Analyses

The key metric for the effectiveness of the 5KH was the elimination of the age and BW biases in RTadj. To ascertain the existence of bias in RT, for each gender, we calculated the Pearson r^2, for RT vs. age, then BW. We did the same for RTadj vs. age, then BW. Given the likelihood that some subjects did not compete at optimal levels, we conducted the above analysis on sub-samples, as defined by faster and faster RTadj times. These were chosen over RT *a priori* based upon our contention that these subsets provided a more accurate indicator of relative effort across the range of age and BW. We hypothesized that, for both genders and as faster sub-samples were considered, the correlations would approach zero in the RTadj condition, thus indicating bias was removed.

RESULTS

Figures 2 and 3 depict the bias analyses for men and women. As hypothesized, the 5KH did remove both age and BW bias, especially when considering the faster runners. In other words, among those who actually ran (not walked or jogged) the course, the age and BW bias against heavier and older runners, which was apparent with RT values, was reduced to near-zero with RTadj values.

Several interesting phenomena were observed. First, for all women (N=126), the 5KH did not appear to reduce the age vs. RT bias, given that the age vs. RTadj r^2 was statistically significant. Similar analyses for the faster women, with RTadj cut-off times of 1560 and 1440 sec, however, indicated that the age vs. RT relationship strengthened and the age vs. RTadj relationship was reduced to near zero. Due to the confounding nature of less-than-maximal effort, this suggests that the 5KH adjustment for age in women was valid. The bias analyses for men suggested more clearly a correct adjustment for age across all samples. Second, when all women (N=126) were considered, no BW bias was evident in the BW vs. RT r^2 value. Not surprisingly, the RTadj, then, had little effect. This would normally suggest no BW bias in the 5K run for women. Again, however, similar analyses but with faster women indicated BW bias in RT and essentially no BW bias in RTadj. Third, the strength of the BW vs. RT relationship, the key indicator of BW bias in the 5K run, was more potent for men than women even among faster runners.

Anecdotal comments from runners were generally quite positive. Many participants expressed appreciation for the overall idea, being recognized as better performers than they had been in the past, and were hopeful that the handicap would be used in future races. The only negative comments tended to be from some women who did not want to be weighed. This reluctance was evidenced in the smaller sample size of women vs. men 5KH participants in the two races, despite near parity by gender overall. Another potential limitation was weigh-in capacity.

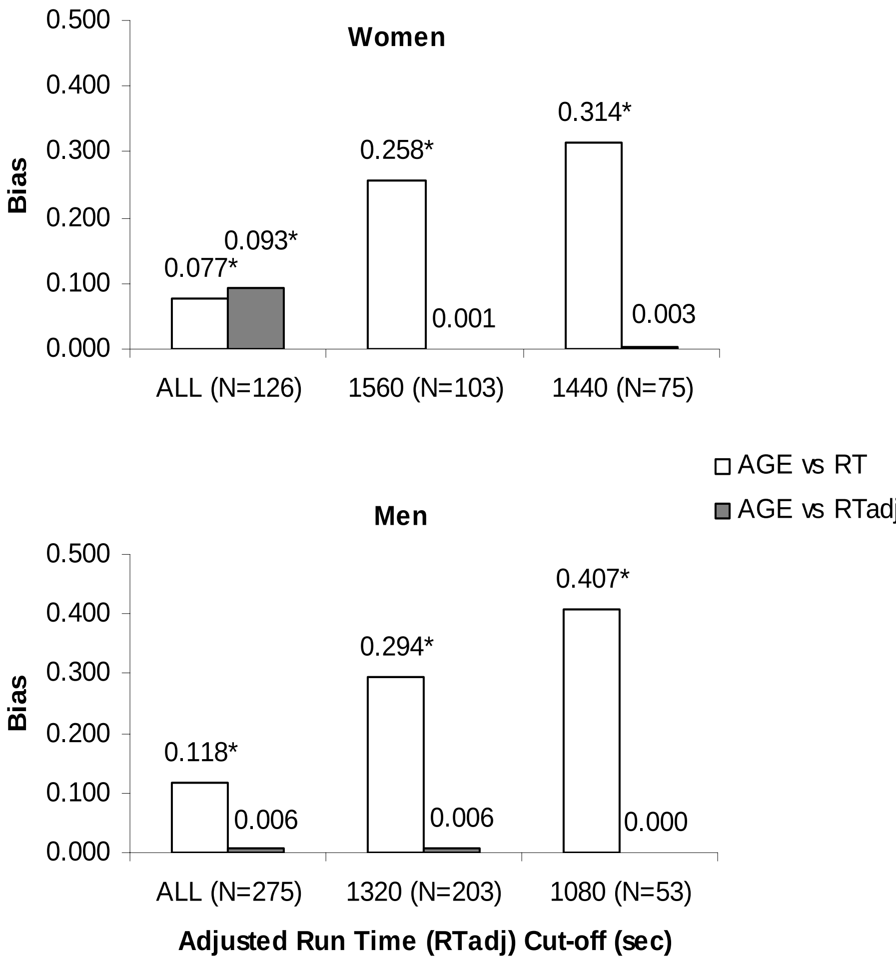

Figure 2. Bias analysis for the 5KH by age. Bias was defined as the Pearson r^2 between age and either actual run time (RT) or adjusted run time (RTadj). *p<0.05

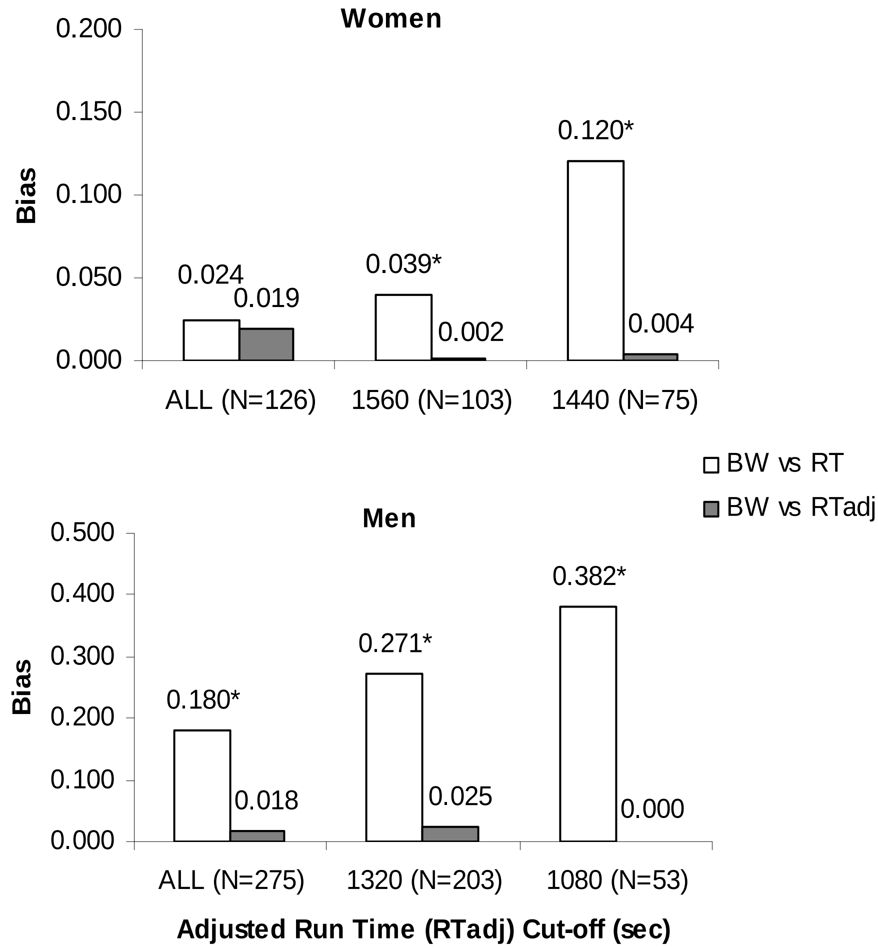

Fig. 3. Bias analysis for the 5KH by body weight (BW). Bias was defined as the Pearson r^2 between BW and either actual run time (RT) or adjusted run time (RTadj). *p<0.05

DISCUSSION

The 5KH appears to remove the age and BW biases associated with 5K run times for both men and women. Consideration of faster runner sub-samples for both genders indicated stronger biases for RT and essentially no bias for RTadj. The trend for smaller BW vs. RT Pearson r^2 values for women, however, cannot be explained in the present data but may be related to gender differences in effort and/or percent body fat. We recommend that this notion be investigated in future study.

While the 5KH web calculator referenced in Fig. 1 is simple to use, there are important procedures and data management issues worth highlighting. First, runners of any age and BW can participate. Younger, lighter runners, however, may receive no handicap, so their RTadj would equal their RT. Heavier, younger adults and lighter, older adults will have handicaps but they may be based only on BW and age, respectively. Second, the 5KH could augment the existing awards structure of any race. In fact, we would recommend using the 5KH in addition to all other awards so that runners' opportunities to be rewarded are maximized. In our more recent of the two races, we offered awards to the top five men and women in the 5KH in addition to the other more standard awards (e.g., Open category, A group, Clydesdale/Filly). The only runners not eligible for the 5KH awards were the top three overall men and women. Surprisingly, few received multiple awards. Third, because the 5KH uses time values which were not conducive to simple mathematical formulas and because the equations are fairly lengthy (ref. 1 contains the full equations for men and women), we encourage use of the downloadable spreadsheet for multiple runners or the web-based calculator for individuals (Fig. 1).

Some might think that by offering a BW handicap, the 5KH may reward excess body fat, which imposes the well-documented effect of slower distance run speed and the higher energy cost at a given run speed (10). A brief analysis of two hypothetical cases shows that the 5KH does not reward increasing body fat. First, a 69.8 kg, 45 yr old woman with a run time of 1800 sec (30:00) would have an RTadj of 1417 sec (23:37). If she gained an additional fat BW of 1.8 kg, with no change in aerobic capacity, then Nevill's equation (4) predicts that she would now have an RT of 1853 sec (30:53) because the excess BW would make her slower. This makes her new RTadj 1441 sec (24:01), a 24 seconds slower RTadj. The more likely scenario is that her aerobic capacity would decrease with such body fat gains, thus contributing to more than the 24 seconds of penalty. In short, body fat gain does not appear to be rewarded in the 5KH.

In a second example, two men, both 55 yrs old, who run the identical time of 1560 sec (26:00), have BWs of 95.2 kg and 102.0 kg, such that the BW difference is due only to excess body fat. Their RTadj would be 1160 sec (19:20) and 1134 sec (18:54) for the lighter and heavier runners, respectively. While one might conclude that excess fat is being rewarded, closer analysis reveals the reverse to be true. The excess fat of the heavier runner is not unlike a weighted vest. If these two runners had the same BW, yet one had to wear a 6.8 kg weighted vest, and both ran 1560 sec (26:00), the runner wearing the vest would be considered "the winner" by most any standard of fairness because his fitness level is higher. Furthermore, if the heavier runner lost the 6.8 kg of excess body fat, with no change in aerobic capacity, his new RTadj, using the same analysis as the women's example above, would be 1454 sec (24:14) and his RTadj would be 1093 sec (18:13), an improvement of 41 seconds. Furthermore, with such body fat loss, his aerobic capacity is likely to improve, thus decreasing his actual RT, thereby contributing to more than a 41 second improvement. Again, body fat loss should be advantageous for the 5KH.

We have received feedback from runners and exercise scientists inquiring why neither height nor body mass index (BMI: weight/height^2) were used in the 5KH. First, we know of no empirical data examining the relationship between BMI or height and distance running performance. Second, neither height nor BMI has been adequately modeled for distance running in the research literature. BW, as discussed previously, fits these inclusion criteria well and has been used and validated in other competitive events including those of muscular strength (11). We do, however, believe that future studies should examine handicapping by height given our observations regarding the reluctance of some women to be weighed.

We are currently investigating methods of applying the 5KH concept to 10K, ½ and full marathons race distances. While the simplicity of scaling up the adjustment factors is appealing, we must be mindful that distance running physiology is different in longer runs, particularly with respect to substrate utilization, glycogen stores, and the ability to regulate body temperature. How these factors would change our assumptions upon which the 5KH is based is not clear. Nevertheless, we believe that similar handicaps for the longer runs are worthwhile objectives.

CONCLUSIONS

The 5KH appears to be valid for men and women in that it eliminates the age and BW biases present in the 5K race. This is especially true when considering faster runners. Furthermore, the BW bias in the 5K run appears to be more potent for men than women for reasons that cannot be elucidated in the present study. Finally, the 5KH appears to reward body fat loss and penalize body fat gain. A web-based calculator and downloadable spreadsheet file are available for quick and user-friendly computations of single and/or multiple scores. Race directors should consider the logistics of weighing interested runners, especially women, who appear less willing to be weighed than men. Finally, we recommend further study of the observed gender-based difference in BW bias as well as validation of this approach with races at the 10K, ½ marathon and marathon distances.

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