Relationships among heart rate monitor usage, neuroticism, and performance in triathletes

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ABSTRACT

Triathlon, a sport that consists of swimming, biking and running, is growing in popularity throughout the country and the world. There is a large percentage of athletes that rely on the use of a heart rate monitor to gauge effort, but there is also a group of athletes that do not use this technology. The purpose of this research was to determine if personality, specifically neuroticism, played a role in determining which athletes use heart rate monitors and whether these variables had any effect on performance. Ninety-eight triathletes were surveyed from 2 half iron distance triathlons in the summer of 2010. There proved to be no interaction effect between neuroticism and heart rate monitor usage on performance [$F\ 2 = 1.830$, $p = 0.168$]. Interestingly, the data showed that there was no significant relationship between heart rate monitor usage and performance. This finding is interesting because heart rate monitors are widely used in the triathlon community, and these data show that perhaps heart rate monitors are not the best tool for gauging effort.

INTRODUCTION

The sport of triathlon consists of three disciplines: swimming, biking, and running. In a race, athletes complete each discipline consecutively with no break in between. The athlete with the fastest overall time is the winner. Races range in distance from sprint triathlons (about 15 miles total) to iron distance triathlons (140.6 miles total) and some even longer than that. Ever since triathlon's inclusion into the Olympics in 2000, the sport has been growing rapidly. More and more people of all ages and fitness levels are getting involved in the sport each year.

Athletes get involved with triathlon for a variety of reasons. Some do it for the exercise, some are professionals and are in it for the money, and others do it for the love of the sport. Regardless of reason for participation, most athletes that race in triathlons are concerned at some level with their performance. Performance in triathlon is measured by overall time. Obviously with a sport consisting of three different disciplines there are many factors that interact to determine performance. Weather, course difficulty, training volume, age, and gender are just a few of the factors that impact overall performance, but this study will focus specifically on heart rate monitor usage and personality traits of athletes (specifically neuroticism) and their interaction effect on performance.

Personality Traits

It is widely accepted in the field of psychology that personality traits play a large role in determining athletic success in any sport. An athlete must possess a certain set of psychological characteristics to perform at their best, but these characteristics differ from person to person and from sport to sport.

Several studies recently have examined personality traits in endurance athletes, including triathletes (Celestino, R., Tapp, J., & Brumet, M. E. 1979; Egloff and Gruhn 1996; Eysenck, H. J., Nias, D. K. B. & Cox, D. N. 1982; Hammermeister and Burton 1995; McKelvie, S. J., Valliant, P. M., & Asu, M. E. 1985). Endurance athletes are an interesting group to study in terms of personality because training and races are more often than not completed individually and over the course of a long period of time compared to most other sports. In a

different sport or race that is shorter in duration, for example, the 100 meter dash, personality traits may not play as large of a factor during competition. In a race that takes 10 seconds to complete versus 10 hours, an athlete has far less time to think about their situation during the race and therefore personality during competition likely has a lesser effect on performance. That is not to say that personality characteristics are not important in other sports, however with endurance sports there is a far greater amount of time for an athlete's personality traits to have an effect on the outcome of the race. In the case of the 100 meter dash, personality traits most likely play a more important role before competition rather than during it.

This is what makes endurance athletes such an important and interesting group to study. Many researchers have tried to determine what (if any) set of personality traits is best correlated to higher performance levels. Do all elite athletes possess a similar mix of personality traits? Are there traits that hinder performance? Do personality traits matter at all when it comes to predicting performance? All of these are questions that researchers throughout the field of sports psychology have been trying to answer.

One important study examined personality traits in endurance athletes, specifically triathletes and long distance runners (Egloff and Gruhn 1996). This study took into account several different personality traits including anxiety, neuroticism and extraversion. The researchers looked into differences in these traits between athletes and non-athletes. Extraverts experience a higher need for stimulation through bodily functioning and therefore are able to tolerate high levels of pain better than introverts (Egloff and Gruhn 1996), therefore as expected, the group of athletes was more extraverted on average than the group of non-athletes and they also reported fewer physical complaints. Extraversion has also been found to be a characteristic of athletes in previous research (Eysenck, *et al.,* 1982). In addition to finding that athletes were more extraverted than non athletes, elite or better performing athletes were found to be more extraverted than the average athlete (Eysenck, *et al.,* 1982). This finding has also been confirmed in other studies (Egloff and Gruhn 1996). Extraversion is one of the few traits that has been consistently found in athletes competing in both team sports and individual sports. It is not surprising that extraversion has been found to be more

prevalent in endurance athletes than the general population, nor is it surprising that elite athletes tend to me more extraverted than average athletes.

Anxiety is another common trait that has been studied in relation to athletic performance in many sports, including its effect on triathletes. It has been found that precompetitive anxiety in iron distance triathletes had no significant effect on performance (Hammermeister and Burton 1995). Due to the long duration of a triathlon race, it makes sense that precompetitive anxiety has little effect on triathletes because once the race begins, the athletes have a far greater amount of time to cope with that precompetitive anxiety than they would in most other sports. As an example, precompetitive anxiety would probably have a far greater effect on overall performance for a 100 meter dash athlete than an athlete competing in an iron distance triathlon. The researchers in this case did find, however, that there was an inverse relationship between performance and the feeling of negative thoughts during the race (Hammermeister and Burton 1995). This information shows that in triathlons, it is more crucial to control anxiety during a race than before it.

Locus of control, which refers to the extent to which a person believes they have control over the situations that affect them, is another psychological trait that has been studied repeatedly in regards to its effect on sports performance, more specifically, differences in locus of control between marathoners and non-marathoners (Celestino, *et al.,* 1979). Using Rotter's Internal-External Locus of Control Scale, it has been shown that there was no significant difference in locus of control scores between finishers of a marathon and non-finishers (Celestino, *et al.,* 1979). Interestingly enough, there was a significant correlation among the marathon finishers between finish time and internality. This means that better finishing times were associated with the individual having a higher sense of internal locus of control (Celestino, *et al.,* 1979).

On the contrary, other studies found differing results when it came to locus of control (McKelvie *et al.* 1985). Other research conducted that studied marathoners found no significant correlation between finishing time and locus of control among the athletes

(McKelvie *et al.* 1985). This contradiction is very interesting and it begs for more research on the topic of locus of control in endurance sports.

Neuroticism is a personality trait that is distinguished by anxiety and instability. It has been linked with several negative life outcomes including low self-esteem and low perceived availability of social support (Swickert and Owens 2010). Those that score high on neuroticism are more likely to respond poorly to stress and are usually unsure of themselves. Typically, those that experience neurotic thoughts in sports environments do not perform as well as their less neurotic counterparts however this is not always the case as there are conflicting reports on the subject (Egloff and Gruhn 1996; Eysenck *et al.* 1982).

When it comes to neuroticism, some have predicted that athletes would score lower on neuroticism than the non-athletes; however results did not support this hypothesis. There was no difference in neuroticism between the athletes tested and the non-athletes (Egloff and Gruhn 1996). This hypothesis was, however, grounded in solid research as many other studies have found a negative relationship between neuroticism and athletic performance (Eysenck *et al.* 1982).

It has been shown that athletes (especially above-average athletes) tend to be less neurotic than their non-athletic counterparts. It is believed that this difference occurs because the anxiety aspect of neuroticism. Neurotic athletes experience higher levels of anxiety during competition and therefore have a more difficult time concentrating on the task at hand (Eysenck *et al.* 1982). Therefore, a less neurotic athlete would theoretically have a higher level of concentration on the task at hand (the race) and be able to perform at a higher level (Egloff and Gruhn 1996). Additionally, it is possible that the lower self esteem experienced by neurotic athletes (Swickert and Owens 2010) would contribute to decreased performance. Logically, this thinking makes sense however as previously stated there have been conflicting results on the topic.

This information presents a puzzling scenario. Some research has shown that neuroticism levels do differ between athletic and non-athletic populations (Eysenck *et al.* 1982) while

other research has shown the complete opposite (Egloff and Gruhn 1996). The differing neuroticism research is very similar to the locus of control research in that both traits have not been definitively connected to performance in endurance athletes. However, although there was no difference in locus of control between marathon finishers and non-finishers, there was a significant correlation between internality and performance *among* the marathon finisher population (Celestino *et al.* 1979). Perhaps there is a similar phenomenon when it comes to neuroticism. Perhaps there is a significant correlation between lower neuroticism levels and better performance *among* the endurance athlete population. Most sports psychology studies that examine differences in personality traits do so between athletes and non-athletes, however few (if any) studies have examined differences in neuroticism within a specific group of athletes.

Neuroticism is a very complicated personality trait. If it does have an effect on overall performance in endurance athletes, it is obviously not a simple causal model. Many other scenarios and events come in to play including the subject that will be discussed in this paper: heart rate monitors. It is plausible that a more neurotic triathlete would be more likely to use a heart rate monitor as a means to assure themselves of their pacing. Others that are less neurotic are perhaps less likely to use a heart rate monitor because they are more confident and can rely on another method, such as rate of perceived exertion, to determine pacing.

Heart Rate Monitors

A heart rate monitor is a device that allows an athlete to keep track of their heart rate during training and races. Usually the device consists of a strap that is worn around the chest which transmits a signal wirelessly to the athletes watch. The athlete can then keep track of their heart rate throughout their training and racing simply by looking at their watch, as it will display their current heart rate. Some athletes train and compete with a heart rate monitor while others do not.

A heart rate monitor is used as a means to gauge effort in a race. It is only one of several methods that can be employed by athletes. One other method is “rate of perceived exertion” in which the athlete tries to measure how hard their body is working using their own internal

scale. Using a power meter is another way to gauge effort in triathlons (although it can only be used during the biking portion). A power meter measures the actual power that an athlete is putting out on the pedals during the biking portion of the race. Triathletes and endurance athletes use one or any combination of these methods in their training and racing. Heart rate monitors have become more popular over the past few decades, especially in the sport of triathlon. Many triathlon coaches will not coach athletes unless they purchase a heart rate monitor. Some athletes do not feel comfortable training or racing unless they have their heart rate monitor with them. In fact, there are a number of anecdotes where an athlete's heart rate monitor has malfunctioned during a race and that athlete went on to have a disastrous race because they panicked and were completely lost without a heart rate monitor to aid in their pacing. Some coaches and scientists warn that an overreliance on heart rate monitors is not beneficial to performance.

Several running and triathlon coaches have explained the reasons why relying completely on a heart rate monitor may hinder performance. Many emphasize the fact that there are several other outside forces that affect heart rate during training and a race, including weather conditions, mood, and stress. With all of these forces affecting an athlete's heart rate, it is difficult to pinpoint exactly which rate the athlete should be training and racing at (Anderson 2006). Success in triathlon and most endurance sports is determined by overall finishing time. The prize purse does not go to the athlete that kept the steadiest heart rate throughout the race. It goes to the athlete with the fastest finishing time. On the same note, a typical age-group athlete bases the success of their race on finishing time, not on their heart rate (Anderson 2006). Despite all this information, heart rate monitors still play a critical role in the training and racing of many triathletes and endurance athletes. That is not to say that heart rate monitors should be deemed ineffective, as many triathletes find great success while using these devices and many coaches base their entire coaching methodology around the use of them. However, it should be noted that perhaps there are other, more beneficial ways for an athlete to determine pacing and improve overall finishing time.

With such an emphasis on the importance of monitoring heart rates in the world of triathlon, it is important to look at the relationship between heart rate and performance in athletes. Several studies have experimented with this relationship, including research that has examined the heart rate/running speed relationship (Boudet, G., Albuisson, E., Bedu, M., and Chamoux, A. 2004). At a constant running speed heart rate will increase over time, and similarly in order to maintain a steady heart rate, running speed must decrease over time. This phenomenon is known as cardiac drift (Dawson, E., Shave, R., George, K., Whyte, G., Ball, D., Gaze, D., & Collinson, P 2005). It has been attempted to determine whether there is a specific level or scale that running speed needs to decrease in order to maintain a steady heart rate (Boudet *et al.* 2004). Results have shown that there is no such scale, and heart rate and running speed are not interchangeable variables. Results have also shown that the relationship between heart rate and running speed can change at any time and that heart rate does not necessarily accurately reflect the work that an athlete's muscles are putting out (Boudet *et al.* 2004).

The previous information showing the lack of relationship between heart rate and running speed has significant implications for triathletes, especially those that use heart rate monitors for training and races. When a typical athlete prepares for a race, they usually have goals in terms of speed for each discipline (swimming, biking, and running). For example, an athlete may want to complete the running portion of a race at 7:30 minutes/mile pace. In many cases, this athlete will also be using a heart rate monitor to gauge their effort. When taking into account the fact that heart rate and running speed are not interchangeable variables (Boudet *et al.* 2004) this method seems counterintuitive. In order to maintain a 7:30 minute/mile pace for the entire race, the athlete would have to allow their heart rate to rise throughout the event. Most athletes who use a heart rate monitor would try to keep their heart rate at a certain level the entire time, making it nearly impossible to maintain a steady pace. Even if this athlete understood the concept of cardiac drift, according to the information presented they would not be able to have a pre-determined scale at which to raise their heart rate throughout the race because the running speed/heart rate relationship can change at any time (Boudet *et al.* 2004).

Neuroticism, Heart Rate Monitors, and Performance

Neuroticism is a very complicated personality trait. Some of the more important aspects of neuroticism include anxiety, stress, and low self-esteem (Eysenck *et al.* 1982; Swickert and Owens 2010). The more neurotic a person is, the greater effect the anxiety, stress, and low self-esteem will have. Given these traits, it is reasonable to hypothesize that a more neurotic athlete would be more likely to use a heart rate monitor than a less neurotic athlete. A more neurotic athlete will look to a heart rate monitor to ease the stress and anxiety during a race. For this more neurotic athlete, the heart rate monitor will also help boost their self-esteem and make them believe they can perform better. Given the previous information about the unreliability of heart rate when it comes to running speed (Boudet *et al.* 2004) it is also plausible to assume that perhaps the use of a heart rate monitor could actually hinder performance rather than improve it.

From this information, three hypotheses are drawn: First, triathletes who are less neurotic are more likely to experience better performance than those who are more neurotic. Second, triathletes who do not use a heart rate monitor are more likely to experience better performance than those who do use a heart rate monitor. Lastly, heart rate monitor usage and neuroticism have an interaction effect such that those who are more neurotic are more likely to use a heart rate monitor and experience lower performance levels than those who are less neurotic and do not use a heart rate monitor.

METHODOLOGY

Data were gathered from athletes who competed in two different races: Mooseman 70.3 and Timberman 70.3. Both of these races are half iron distance triathlons which consist of a 1.2 mile swim, 56 mile bike, and 13.1 mile run. Mooseman 70.3 was held on June 6, 2010 in Bristol, New Hampshire, and Timberman 70.3 was held on August 22, 2010 in Gilford, New Hampshire. Both courses are relatively similar and both races took place in relatively similar conditions.

Neuroticism was measured using the NEO Five Factor Inventory (NEO-FFI) which is a widely accepted tool for measuring personality characteristics in the field of psychology. The

NEO-FFI was developed by Paul T. Costa, Jr., Ph.D. & Robert R. McCrae, Ph.D in 1992 (SIGMA Assessment Services, 2011). The NEO-FFI scales have shown correlations of .75 to .89 with the validity of the full length NEO Personality Inventory. Additionally, the NEO-FFI has internal consistency values ranging from .74 to .89 (SIGMA Assessment Services, 2011).

The original NEO-FFI contains 60 questions pertaining to openness, conscientiousness, extraversion, agreeableness, and neuroticism. However, since it was already a difficult task to solicit athletes who were competing in a 5+ hour race for participation in this survey, only the 12 questions pertaining to neuroticism were asked in order to keep the entire survey as short and as easy to complete as possible. For the purpose of analyzing the data, neuroticism was scored on a 'low, medium, high" scale with a score of 0 to 10 being "low," a score of 11 to 21 being "medium" and a score of 22 or higher being "high."

Heart rate monitor usage was measured with a simple "yes or no" question. Participants were asked if they use a heart rate monitor during races as well as if they use a heart rate monitor during training. Performance was measured in terms of overall finishing time. Finishing times were retrieved from the official race results section of each race's respective website (World Triathlon Corporation 2011). In the event that an athlete competed in both Mooseman 70.3 and Timberman 70.3 the faster of their two times was used for the results. All aspects of this survey and study were approved by the Bryant University Institutional Review Board on May 11, 2010.

All data were gathered from athletes through a survey. The survey was either given in a face-to-face setting at the respective race expo before or after the race. Athletes were also solicited for participation through online forums (Slowtwitch.com, Beginnertriathlete.com, or Endorfunsports.com) in which case the athlete took the survey online. Participants were selected for the study using a convenience sample. Prior to receiving the survey, participants were asked to sign an informed consent form. With online surveys, informed consent was given online. After giving consent, participants completed the survey themselves, filling in all necessary information.

RESULTS

A total of 98 athletes participated in the study. Twenty-two of the athletes participated in only Mooseman 70.3, 61 of the athletes participated in only Timberman 70.3, and 14 of the athletes participated in both races. One athlete failed to report which race he/she competed in. Sixty-nine of the participants were males while 29 were female. Eighty-four of the participants resided in the Northeast, 4 resided in the South east, 1 resided in the Midwest, 1 resided on the West coast, and 8 of the participants resided abroad. Eighty-four of the athletes had at least a college (4 year) education or higher. Twenty-five of the athletes reported having a coach while 73 reported not having a coach. Ninety participants reported their ethnicity as Caucasian, 3 reported Hispanic, 1 reported African American, and 2 reported Asian Pacific Islander. The remaining 2 participants did not disclose their ethnicity.

Ages ranged from 19 to 62 with a mean age of 38.28 and standard deviation of 8.87. Finishing times ranged from 4:23:45 to 8:57:19 with a mean finishing time of 5:51:02 and standard deviation of 58:46. Neuroticism scores ranged from 2 to 33 with a mean neuroticism score of 13.79 and standard deviation of 7.04.

Fifty-six of the athletes reported using a heart rate monitor during *training* while 42 reported not using a heart rate monitor during *training*. Forty of the athletes reported using a heart rate monitor during *races* while 58 reported not using a heart rate monitor during *races*.

Data were analyzed with a 2x3 factorial design using Analysis of Covariance (ANCOVA). Heart rate monitor usage and neuroticism were the independent variables and overall time as the dependent variable. Age was the main covariant.

Results of the ANCOVA showed that there was no statistically significant main effect between neuroticism and performance (time) [$F(2) = 0.763$, $p = 0.470$]. There was also no significant main effect between heart rate monitor usage (in competition) and performance (time) [$F(1) = 1.202$, $p = 0.277$]. In addition, there was no interaction effect between neuroticism and heart rate monitor usage (in competition) on performance [$F(2) = 1.830$, $p = 0.168$].

Heart rate monitor usage *during competition* was used rather than heart rate monitor usage *in training* in the ANCOVA because it was more logical to test heart rate monitor's effect on performance in an actual race situation. Heart rate monitor usage in training was also tested using the same ANCOVA design and similar results were found (no statistically significant effect).

Heart rate monitor usage (in competition) was found to have no significant correlation with performance. The same was true for heart rate monitor usage during training.

DISCUSSION

After reviewing the data, it was clear that none of the three hypotheses were supported. There was no significant interaction effect between heart rate monitor usage and neuroticism on overall performance. Also, heart rate monitor usage alone had no significant effect on overall performance and neither did neuroticism.

There were several limitations to this study. Triathlon is an inherently difficult sport to study due to the sheer difficulty and length of the events. It is also a relatively small sport compared to other more popular sports in terms of the number of events per year. In this study, athletes had to be solicited either online or at the actual race site because race officials would not allow solicitation through official race materials. Both events also experienced rain which made it difficult to solicit athletes with paper surveys.

Because of the difficult of solicitation, the data were collected using a convenience sample. This could have affected the results since the data were not collected completely at random. Not every athlete had the opportunity to participate in the study because there were over 3000 athletes in both events combined making it nearly impossible to solicit every athlete in person. Also, it can be argued that those athletes who are actually more neurotic would be less likely to take the survey just based on the personality trait itself.

These results showed that neuroticism had no effect on performance within the triathlon population which is a similar to the findings of past studies (Egloff and Gruhn 1996; Eysenck

et al. 1982). In other words, the results showed that faster athletes are no more or less neurotic than slower athletes.

All of these results, however, are conflicting with the results found in the past concerning marathoners where it was determined that faster marathoners have a more internal locus of control than do slower marathoners (Celestino *et al.* 1979). Although locus of control and neuroticism are not the exact same personality trait, they are very similar on many levels. It is reasonable to believe that neuroticism and locus of control are somehow linked based on the information presented in this study. Therefore, it would be reasonable to assume that a faster triathlete would be less neurotic than a slower triathlete, but obviously the results from this study did not support this hypothesis. Again, this could be because although they are very similar personality traits, neuroticism and locus of control are not exactly the same.

One reason for this discrepancy could be the fact that the subjects in one study (Celestino *et al.* 1979) were marathon runners, and the subjects in this study were triathletes. Although triathlons and marathons are both considered endurance events, they are inherently different on many levels. The obvious difference is the fact that triathlon consists of swimming, biking, and running, while a marathon consists solely of running. It is also important to note the difference in duration of the two types of races. The subjects in this study were participating in a half iron distance triathlon which is much longer (in terms of time and distance traveled) than a marathon. Although there are triathlons that are shorter in duration, many of the popular distances are at the half iron distance or even longer. Because of the duration of the races, an athlete participating in half iron distance triathlon would have to put in much longer training hours than a marathoner in order to be successful. The obvious differences in the nature of the two types of races could explain why the results from previous research (Celestino *et al.* 1979) differ from the results of this study.

Despite the information presented concerning overreliance on heart rate monitors and decreased performance (Anderson 2006), results of this study showed that heart rate monitor usage in triathletes does not decrease performance. It is, however, very important to note that there was no statistically significant relationship between heart rate monitor usage and

performance. Most of the triathletes in this study who reported using heart rate monitors indicated that they did so because they believed that it would somehow enhance their performance. According to the results, those that used heart rate monitors during competition experienced no better performance than those who did not use heart rate monitors. Perhaps there is a better way to determine pacing than using heart rate monitors.

If the use of heart rate monitors provides no added benefits to triathletes or there is a better way to determine pacing, the effect on the sport of triathlon would be enormous. A significant percentage of triathletes rely on heart rate monitors during races (in this study, 40.8%) and many coaches base their whole training methodology on heart rate. If basing pacing on heart rate provides no benefit, then triathletes have been wasting time, energy, and money obsessing over their heart rate monitors and perhaps even hindering their performance in the process. The data suggest that a heart rate monitor has no effect on performance, however before any conclusions are drawn it is necessary for much more extensive research to be conducted on the topic.

If it proves to be true that heart rate monitors do not improve performance in triathletes, the implications could extend far beyond the sport of triathlon. Heart rate is an integral part of numerous sports and exercising for many people. From the occasional runner who uses the heart rate handles on a treadmill to measure progress, to the marathoner who owns an expensive heart rate monitor for pacing during races, to the endurance athlete coach who bases their whole methodology for training on heart rate, people across the world use and rely on measuring heart rate. If it is in fact not the best way to determine effort, there would be a great impact across the sport and exercise world. Obviously, any findings are far from conclusive, but more research should definitely be conducted on the subject to gain a better insight on the situation. The nature of the sport makes it inherently difficult to study. Ideally, a subject would be told to train and compete in a race with the use of a heart rate monitor, and then asked to train and compete in the same race (with all other variables held constant) with no heart rate monitor. Obviously, this type of study would be nearly impossible to conduct. A more reasonable study could have a similar set-up, however instead of competing in

triathlons, athletes would be asked to complete 2 much shorter, single-sport races. For example, an athlete could complete 2 one-mile runs. One race would be completed with the use of a heart rate monitor and one would be completed with no heart rate monitor. Theoretically, these races could be completed within a small time frame (1-3 days) provided there was adequate rest for the athlete.

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