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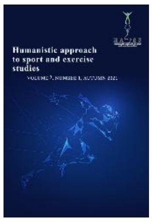


*Original Article*

# Physiological Patterning of basketball free throws

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**Abstract:** A few second prior to an expected event, a systematic decrease in heart rate (HR), reflecting attentional processing is observed. Arousal variations however, restrain the interpretation of this decrement. The present study, aimed to investigate vigilance and arousal effects during a skilled performance separately, using separate measures for the two psychological states. HR and skin conductance level (SCL) were measured as an index of vigilance and arousal from 18 elite and 19 novices during 30 self-paced, self-initiated basketball free throws. Values of HR and SCL were calculated at half-second intervals from 10 s before to 10 s after each shot and were analyzed using repeated measures ANOVA. This helped to compare pre-shot and post-shot patterns of physiological changes separately in elites and novices. In elites, there was a slow reduction in SCL prior to, and a rebound increase immediately following the shot. These were smaller for novices. Similar findings were observed when good shots were compared to bad ones. The value for rebound after good shots reached 8 times more than the pre-shot value. A sharp increase in HR, up to 40 bpm was found 4 second before the shot, which returned to pre-shot value after 2s for elites; this did not return in novices. HR in bad shots was higher than good shots. Results indicate that the SCL reflect arousal level at the time of task and its pattern of variations reflects skill level. Although, HR was lower in good shots, the pattern of variation in HR reflected physical requirements of the task. Results were compared to previous findings and discussed in relation to the hypotheses explaining arousal and vigilance in human behavioral performance.

**Keywords:** Skin conductance level, Arousal, Heart rate, Vigilance, Basketball free throw, Psychophysiology;

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## 1. Introduction

Heart rate deceleration has been known for a long time to reflect attentional processing (Lacey, Bateman & Vanlehn 1953; Lacey, 1970 & Lacey, 1974)). Anticipatory HR deceleration is a systematic change in HR few seconds prior to an expected event which demands attentional processing. This psychophysiological response accompanied with increased attention to the related stimulus, was for the first time introduced by Lacey (1967) and lacey and lacey (1970) and later on verified by Stern (1976), Brunia (1984) Brunia and Damen (1985) and Tremayne and Barry (Tremayne & Barry, 1990; Tremayne & Barry, 2001). Functional studies showed that HR deceleration correlates with the type and level of skill and reflects individual and intra-individual differences in sport capabilities Barry (Tremayne & Barry, 1990; Tremayne & Barry, 2001; Wang & Landers, 1986). HR deceleration is explained by the Intake- rejection hypothesis which states that stimulus intake is accompanied with cardiac deactivation or deceleration, while stimulus rejection is associated with cardiac activation or acceleration. Lacey and Lacey developed this hypothesis to the visceral afferent feedback model (Lacey, 1970 & Lacey, 1974) which states that tachycardia increases hypertension which in turn activates baroreceptors and eventually reduces sensorimotor efficiency. Accelerated HR reduces the cortical response to the environmental stimuli; this is caused by increased bulbar inhibition upon the reticular formation. Such a reduction in external noise may alleviate internal cognitive processing. On the contrary, decelerated HR reduces bulbar control upon the cortex and facilitates processing of external stimuli (Hatfield, Landers & Ray, 1987).

While Lacey's point of view gave emphasis to the role of attentional processes on cardiac activity, there are also other explanations to the subject of HR variations in attentional situations. On one hand, Obrist (Obrist, 1981) stated that HR deceleration may well caused by reduction in motor activity, not by attentional processes. On the other hand, Brunia (Brunia, 1984) verified HR reduction during response preparation, but deemphasized the effect of motor activity on HR variations, since he found that HR deceleration prior to participant's response was not associated with general decrease in muscular activity; he found that the decrease in activity was commonly restricted to small muscles. His results did not support Obrist's view point. A third view point which claims that both attentional processing and motor preparation are involved in skilled performance involving a motor movement such as a Basketball free throw. Using EEG measure, Damen and Brunia (1987) provided evidence for the effect of joint activation of these two processes on HR deceleration in a time estimation task.

Richards and Casey (1991) characterized three patterns in HR variations and related them to three phases in the attentional behavior. A sustained lower mean HR with lower variability was accompanied with visual sustained attention. Initial reactions to a stimulus and disengagement of attention from it were accompanied with HR deceleration and HR acceleration, respectively. One of the important findings of Richards and Casey's study was the increased duration of HR deceleration and the slower recovery of HR when distraction occurs, was related to greater engagement with the attentional task. Tremayne and Barry (2001) considered this finding a development in the conceptualization of cardiac functioning and found it of particular relevance in the shooting context. They used this paradigm to study physiological patterning of best vs. worst shots in elite pistol shooters.

It is important to say HR deceleration as a general response does not any significance unless one can relate them to individual or intra-individual differences; otherwise, there will be no need to investigate them. To some extent, functional studies on HR deceleration showed that individual and intra individual differences correlates with skill level and the type of task involved. For example, Wang and Landers (2022) found that HR deceleration was evident both for novices and elite archers, but more observable for elite archers in the aiming period. A similar finding was reported by Tremayne and Barry for HR variations in pistol shooters. The significance of these findings is the fact that the rate of HR deceleration in self-paced sport activities associates with the performer's skill level. These findings provide us with evidence which indicates that the HR deceleration is not a general physiologic response, rather a reflection of individual difference in performance capabilities. It seems that arousal changes in some of these studies prevented us from the interpretation of attentional effects. Since these studies did not use a proper physiological measure to measure arousal, a rather complicated state variable, the interpretation of findings is rather difficult. This was until Tremayne and Barry published their report on HR and SCL pattern of changes in elite and novice shooters; therefore, arousal effects distinguished from attentional HR effects.

In this research, the changes related to the level of Skin conductivity level (SCL) and heart rate were used separately, as two indicators, to measure two different psychological states. Most of the primary studies (Lacey, 1970) have shown that simultaneously with the change in task demands, different scales that are used to measure arousal, such as heart rate, blood pressure, and conductivity activity of the skin, are separated from each other. For this reason, all of them cannot be the most accurate indication of arousal.

The use of different scales to measure arousal caused confusion in psychophysiology research, until recently, Termin and Berry (Tremayne & Barry, 2001 & Tremayne & Barry, 1994) and Berry (Barry,



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1996) used SCL as an index of arousal to overcome this impasse. Besides they introduced the use of heart rate as an indicator of alertness - which is an attentional state related to expected cognitive/perceptual or behavioral activity that is independent of arousal. They claimed that the use of these two scales separates the effects of arousal from the effects of attention and removes the doubt that the change in the level of arousal hinders the interpretation of the effects of attention. They suggested that the separate measurement of these two variables with two separate scales of SCL (arousal) and heart rate (alertness) would be more beneficial than the weak measurement of one variable with two scales. SCL, which shows electrical changes related to the activity of sweat glands (which are mostly concentrated on the surface of the palms and soles), has a long history as an arousal index in psychology and is still used as a golden index in measuring arousal (Barry & Sokolov, 1993).

The effectiveness of Tremin and Berry's proposal (Tremayne & Barry, 2001) in the study of shooters' performance created the necessary ground to test it in the study of another skill that has different physical and perceptual/cognitive demands. Interpretation of the effect of attention processes on cardiac activity, compared to what was presented by Lacy and Lacy (Lacey, 1974 & Lacey, 1980) and on SCL, compared to what was suggested by Tremin and Barry (Tremayne & Barry, 2001), in the basketball free throw skill, giving meaning to the heart function and SCL. Therefore, the question of the current research is, how the quality of alertness is, as measured by heart rate, and the state of arousal, as measured by the level of electrical conductivity of the skin, before the basketball free throw? How fast will it be compensated? What difference does skill level make in the physiological profile of athletes? And what is the relationship between the obtained physiological profile and the performance of athletes?.

## 2. Methods

### 2-1. Subjects

18 skilled basketball players (7 men, 11 women; age range 19-44, average 24.3 years) who play in the country's premier basketball league participated in this research. The control group included 19 students of the basketball training class (5 men, 14 women; age range 20 to 43, average 26.3 years) who had completed one to three basketball training sessions. This number is enough to achieve statistical power of 0.8 at a significant level of 0.5 (Aron & Aron, 1994).

### 2-2. Tools and data processing

Each subject performed the basketball free throw task 30 times with a standard distance. The portable device "Biograph Infinite" manufactured by "Thought Technology Canada" was used to record data. "EKG-Flex/Pro" triple pressure sensor and standard gel were used to record cardiac activity. The negative electrode was installed on the right shoulder, the positive electrode was installed on Xyphoied process, and the ground electrode was installed on the left shoulder. To record SCL, "SC-Flex/Pro" electrodes were installed in the large medial arch of the non-superior foot at a distance of two and a half centimeters (Tremayne & Barry, 2001, 21). All data were collected at a frequency of 256 Hz and recorded at a frequency of 32 Hz.

In order to control the psychological variables, the Brunel Mood Scale (BRUMS) was used. This scale was made using the profile of mood states of BRUMS and it has no implementation and interpretation problems (Terry & Lane, 2003). This scale includes 24 simple mood descriptors that measure the six moods of tension, depression, anger, vitality, fatigue and confusion. Respondents indicate whether they have experienced such a feeling by marking on a 5-point scale (zero = never, one = a little, two = moderately, three = a lot, and four = very much). It takes about one to two minutes to fill in the BRUMS questionnaire, and in this sense, it is completely superior to the Pams. Reducing the number of questions is another advantage of the BRUMS questionnaire, which makes it possible to use it for young subjects.

The subjects' performance in basketball throwing was scored in a simple way: goal is equal to 1, and out is equal to zero, with the assumption that its simplicity and clarity will make it easy to interpret the results.

### 2-3. Data Collection Process

Electrodes were attached while the participants were seated in a chair. Each subject was given twenty minutes to get used to the electrodes. On this occasion, the subjects were able to wear their socks and shoes and walk with the electrodes. Then Broms Mood Inventory was given to the subjects to record their feelings at that moment. After that, the subjects stood at the throw site and prepared for the main throw after 5 practice throws. They made the throws one after another with the desired speed. After collecting the balls from under the basket, two assistants returned them to the subject. Another assistant recorded the result of the throw.

### 2-4. Statistical Methods

The average level of SCL and heart rate were calculated every half second for 10 seconds before and 10 seconds after the throw (40 data points in total) and were used for statistical calculation. Profiles of the average level of physiological responses during 3 throws were analyzed by analysis of variance with repeated measures that measured pre-throw and post-throw patterns separately in experts and beginners. This analysis included selected orthogonal trends on repeated measures to avoid the problem of inhomogeneous variance-covariance matrix that is often associated with physiological data of repeated measures analysis of variance.



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The data related to the group of experts was divided into two categories: profile of good answers and profile of bad answers on the time axis. Each group of data was analyzed separately by means of a repeated measures analysis of variance comparing the immediately pre-throw pattern with the immediate post-throw pattern and including a factor to test the effect of "performance" (good vs. bad). A significant level ($p>0.5$) was considered. Finally, the correlation of skin and cardiac responses within each subject was tested to determine how much these two shares in measuring a single structure.

## 3. Results

### 3-1. Performance Scores

Throws that went into the basket were called "good throws". Unscored throws were labeled as "bad throws." Each skilled subject made between 2 and 21 (mean=10.66, standard deviation=6.16) good throws. Each novice subject made between 0 and 11 good throws (mean = 4.57, standard deviation = 3.22). The number of good throws in the skilled group was higher than that of the beginner group ($F1, 35=14.40$; $P>0.1$).

### 3-1. The scores of the psychological variables of the expert group

The use of twenty-four question "Brooms" mood test showed that the average score of the participants' self-measurement in the variable of tension is equal to 1.66, in the variable of anger equal to 1.47, in the variable of fatigue equal to 2.09, in the variable of confusion, it was equal to 1.76, in the variable of vitality it was equal to 9.61, and in the variable of depression it was equal to 1.28. According to the published norm, the scores of all negative moods were less than the 50th percentile. This indicates that the participants were in normal mood. The score of positive mood of vitality was more than the 50th percentile and it was expected.

### 3-2. SCL

Figure 1 shows the graph of all throws compared to the group average against the time axis for both experts (mean = 9.50, standard deviation = 0.21 microsiemens) and beginners (mean = 5.72, standard deviation = 0.10 microsiemens). During the 10 seconds before the throw, the SCL of the skilled group was higher (9.32 > 5.64) than the beginner group ($F1, 35 = 92.4$; $P < 0.05$). In the expert group, from the time of data recording, that is, ten seconds before the throw, an obvious decrease in the profile of the electrical response of the skin was observed, which continued until two seconds before the throw. This linear decrease on the time axis was statistically significant ($F1, 17 = 22.41$; $P < 0.001$). A linear decrease in the electrical activity of the skin was also observed in beginner throwers ($F1, 18=21.65$; $P<0.001$); However, this reduction was slightly less than the skilled group ($F1, 35=50.6$; $P <0.05$). About one second after the throw, SCL returned to the pre-throw level and peaked in the third second after the throw, and then tended to the initial level.

This return in the skilled group was in the form of a significant tendency of the Quadratic trend ($F1, 17=18.96$; $P <0.001$) and the third degree $F1, 17=40.6$; ($P<0.05$) was observed on the time axis.

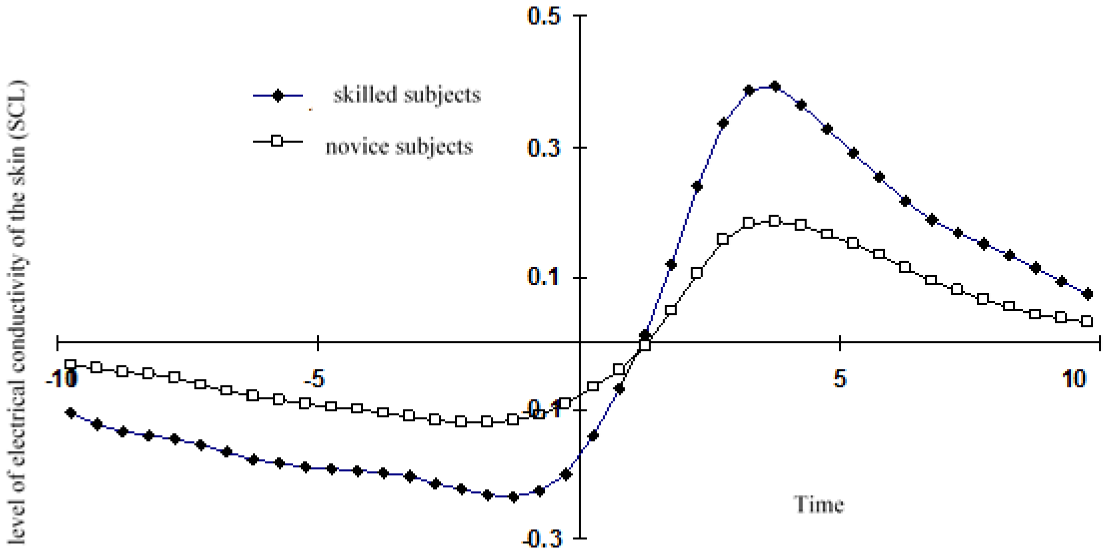


**Figure 1.** Changes in the level of electrical conductivity of the skin (SCL) of skilled subjects (dashed line) and novice subjects (light line) ten seconds before and ten seconds after a basketball free throw. A linear decrease of SCL up to two



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seconds before the throw and its rapid increase up to three seconds after the throw are observed in both groups. The changes before and after the throw are more in the skilled group. It should be noted that the curves in this figure are drawn in order to compare the changes made according to the average of the group and do not show the actual figures.

In the beginner group, this mutation was seen in the form of the Quadratic trend ($F1, 18 = 56.30$; $P < 0.001$) and a third-order trend ($F1, 18 = 3.74$; $P = 0.07$) was almost significant. Although the average of the SCL after the throw was lower than that of the beginner group (5.78<9.63), it peaked about 2 microsiemens more than the beginner group compared to its previous level. The SCL related to the skilled group for good throws and bad throws are shown separately in Figure 2. Although, in general, SCL in good throws (mean = 9.42) seemed to be lower than bad throws (mean = 9.90), but the SCL overall level of the two throws did not show a significant difference ($F<1$). In good throws, there is a significant linear tendency ($F1, 17 = 10.45$; $P < 0.01$) and an almost significant quadratic tendency ($F1, 17 = 4.12$; $P = 0.58$). shows. In bad throws, only the linear tendency was significant ($F1, 17 = 15.67$; $P < 0.01$). From two seconds before to three seconds after the throw, SCL compensatory jump upwards was observed. After good throws, SCL gained about 3 microsiemens more height.

In an attempt to determine the timing of these changes in skin electricity, the maximum level before the throw, the minimum level after the throw, the maximum return after the throw, and their corresponding levels were calculated for the good throws and bad throws of the expert group. Figure 2 shows that there was no difference between the two groups.

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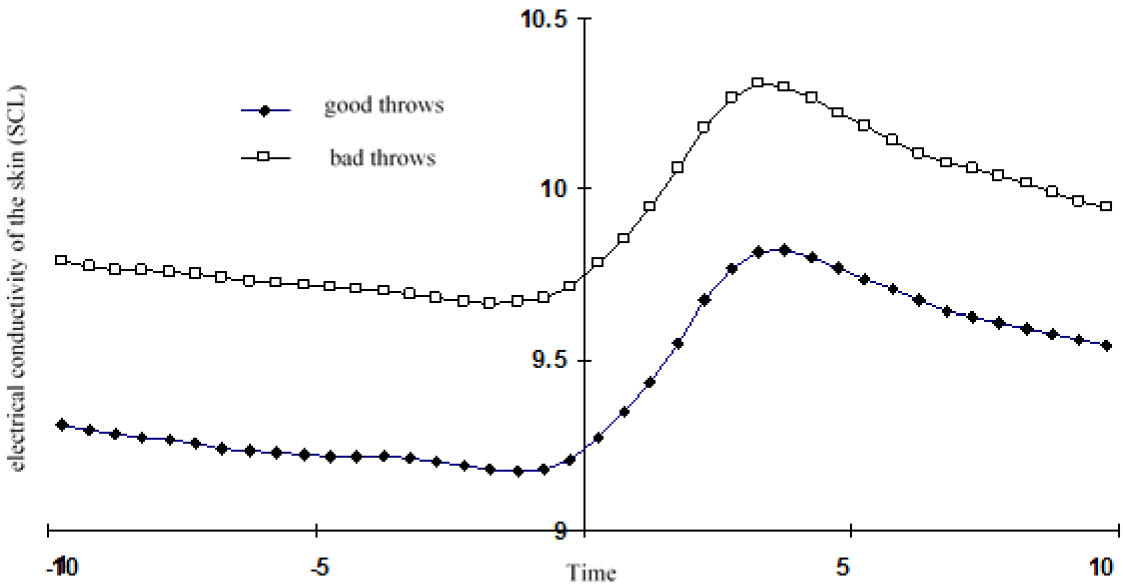


**Figure 2.** Changes in the electrical conductivity of the skin (SCL) of the skilled group in good throws (dashed line) and bad throws (thin line) ten seconds before and ten seconds after the throw. SCL is a little lower in good throws and its compensation after the throw is more.

## 3-3. Cardiac Activity

Figure 3 shows the cardiac profile related to the intra-group average of all throws separately for the expert group (mean 108.28, standard deviation 19.11 beats per minute) and beginners (mean 121.70, standard deviation 21.01 beats per minute). Before the throw, the average heart rate in the two groups did not differ from each other ($P = 0.170$), which shows the high variability of the heart rate in the two groups. The experts showed a uniform heart rate until about 5 seconds before the throw. Linear tendency ($p=0.09$), quadratic ($p=0.54$), and third level ($p=0.70$) were not significant. At this time, the heart rate began to increase to about 39 beats per minute until one second after the throw. Linear tendency ($F1, 17 = 55.04$; $P < 0.001$) and quadratic ($F1, 17 = 46.78$; $P < 0.001$) were significant. The heart rate change in beginners had a different form.

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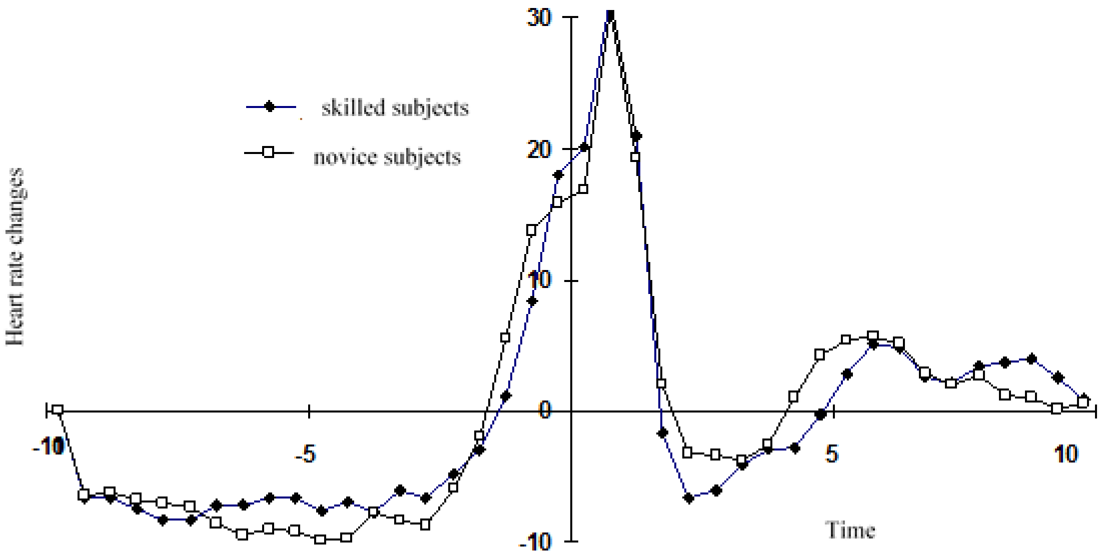


**Figure 3.** Heart rate changes of expert and beginner group before basketball free throw. The heart rate seems steady until about three seconds before the throw. From then on, there is a rapid increase in heart rate up to about 40 beats per minute, which is accompanied by a rapid decrease after the throw. Although the heart rate of the two groups was different, the linear tendency to go down and up was not different in the two groups; The heart rate in the beginner group did not return to the pre-throw level. Note that this figure is drawn according to the average of the group to show the heart rate changes, not the actual number.

From 10 seconds to 4 seconds before throw, a three-stroke decrease in heart rate was observed (F1, 17=5.01; P <0.05). After that, a systematic increase similar to the skilled group was seen (F1, 17=49.08; P<0.001). This increase in the skilled group was followed two seconds after the throw by a rapid return to the pre-throw minimum, an increase of about 13 beats at 6 seconds after the throw, and a slow return to baseline. Linear tendency (F1, 17 = 3.73; P = 0.07) and quadratic tendency F1, 17 = 53.14; P<0.001)) and the third degree F1, 17=52.37; P < 0.001) was significant. In the beginner group, the heart rate never returned to the initial level. The maximum return of the heart rate in this group was three seconds after the throw; after that, an increase of about 9 hits and finally a slow return was observed. Linear tendency (F1, 18 = 12.94; P < 0.01), quadratic (F1, 18 = 31.97; P < 0.001), and third degree (F1, 18 = 61.14; P < 0.001) was significant. The heart rate of the two groups after the throw was different from each other (F1, 35=8.36; P <0.01).

Cardiac data of skilled group in two categories of good throws and bad throws are shown in Figure 4.

Heart rate in good throws (mean 108.56, standard deviation 9.24 bpm) was slightly lower than heart rate in bad throws (mean 112.99, standard deviation 10.48 bpm). It increased its rate to about 45 beats per minute (F1, 17 = 66.71; P < 0.001). Heart rate in bad throws was monotonic from 10 to 5 seconds before the throw (F<1); and from then until one second after the throw, it increased to about 42 beats per minute (F1, 17 = 90.20; P < 0.001). From the 2nd second after the throw, a linear return of the heart rate to the pre-throw level was visible. This return was almost simultaneous in both types of throws; however, after bad throws, heart rate was still higher than after good throws. From the 2nd second after good throws about 17 beats and after bad throws (about 11 beats) a gradual increase was observed. Linear tendency (F1, 17=3.26; P =0.08) and quadratic (F1, 17=6.14; P <0.05) in good throws, and linear tendency (F1, 17=5.79; P<0.05) was significant in bad throws. The difference in heart rate between the two groups after the throw was significant (F1, 35=291.15; P <0.001).

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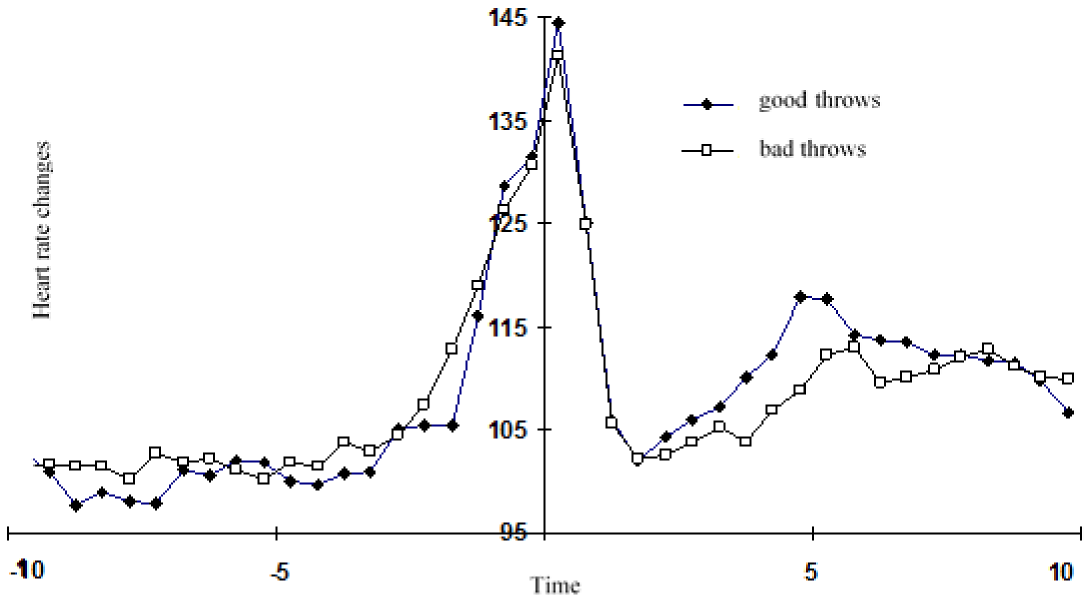


**Figure 4.** Changes in heart rate of skilled group, before and after good and bad throws. Heart rate was generally lower in good throws than in bad throws. The heart rate seemed steady until about three seconds before the throw. From then on, a rapid increase (40 beats in good throws and 44 beats in bad throws) in heart rate was observed, followed by a rapid decrease to approximately the initial level after the throw.

### 3-4. Comparison of Cardiac and Skin Electrical (SCL) Profiles

Correlations of electrical skin responses and cardiac responses were calculated in each skilled participant to determine the extent to which these two indices were measuring a single construct. Due to the two-second delay in the electrical system of the skin, the first 64 data points of the electrical response profiles for good and bad throws were discarded, and thus the data of the third second were compared with the data points of the first second of the cardiac profile (a total of 576 points from each data set). The correlation coefficient between 0.70 up to - 0.75 and its average calculated through Fisher's Z was equal to -0.03. Although this correlation coefficient is slightly higher than zero, the coefficient of determination (r2) is equal to 0.001, less than 0.05 which showed that the two scales share less than 05% of the variance of each other's changes.

## 4. Discussion

The mood scales of the skilled group showed that the mood of the subjects in this group was normal. The importance of the normality of subjects' mood is because mood changes may change the level of arousal and make data interpretation difficult. This, in turn, will reduce the generalizability of the findings. The overall performance level of the expert group (mean = 10.66) compared to the beginner group (mean = 4.57) confirmed their expert status.

If we consider the electrical activity of the skin as a reflection of the individual's moment-to-moment state of arousal as pointed out by Berry and Sokoloff (1993), Figure 1 shows a systematic decrease in the arousal of the skilled group before the throw which immediately returns to baseline after throw and is followed by a compensatory jump. Skilled throwers showed greater reduction in pre-throw SCL and greater post-throw compensation. Therefore, it can be concluded that the greater deceleration before the throw and greater compensation after the throw is a response profile related to skillful execution rather than the physical demands of the throw such as holding the ball up and releasing it.

Tremin and Barry (2001) reported a greater decrease in the SCL of experienced shooters than novice shooters 5 seconds before the shot. The reduction of the SCL in this research was significant from 10 seconds before the throw when the data recording started. It seems that the difference in physical demands and task attention in the two researches is the foundation of the interpretation of this finding.

The good throws of the skilled group had less SCL from the beginning of the data recording, thus showing evidence of relatively less activation in the good throws. This difference did not exceed the significant limit during the ten seconds before the throw. Thus, electrical skin data show that the activation level is lower for good throws. A systematic decrease in pre-throw activation separated good and bad throws. The state of the SCL before the throw can be examined from two aspects: first, in terms of its general reduction until the throw time, which is observed in good and bad throws. We


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interpret the general decrease in pre-throw activation as relaxation or stabilization prior to skilled task performance and attribute the more linear decrease of good throws to it. Second, the general difference in activation level, which averages lower in good throws. It appears that the difference in activation level implies better performance in experts. This finding is contrary to the findings of Tremin and Barry (Tremayne & Barry, 2001) in two ways: first, the linear decrease of the SCL, which was observed in the study of Tremin and Barry only in the skilled group; Second, the lack of difference in proficiency in that research between the subjects of the two groups of beginners and experts.

After the throw, the skilled throwers showed a compensatory jump in the electrical activity of the skin, which was about twice as large as the compensatory jump of the novice group. The compensatory bounce difference between good and bad throws increased by up to three times. Thus, it appears that the compensatory return of the SCL after the throw, relative to the decrease before it, reflects the level of skill in the execution. Tremin and Berry (2001) did not find this difference between good and bad shots. In this way, they considered this phenomenon independent of implementation. Unlike Tremin and Barry, the present study does not confirm the independence of the execution outcome from the activation changes in skilled throwers.

Contrary to what was expected from the Lassie studies (e.g., 3. Lacey & Lacey, 1970), there was no regular decrease in the heart rate of the novice and expert before the throw. Previous studies (such as Tremayne & Barry, 1990) that followed Lassie's studies in identifying a decrease in heart rate with an increase in tinnitus confirmed the existence of this phenomenon. In the context of the present study, alertness refers to a state of attention in which the focus is on the external stimulus. In this research, it can be considered as focusing on the basketball hoop. Decreased heart rate as a sign of tinnitus was clearly observed in the previous report of Tremin and Barry (Tremayne & Barry, 2001). According to their interpretation, this phenomenon indicated that a significant narrowing of the sight/target connection ratio in skilled shooters is facilitated by heart rate, which continues until the time of throwing. However, the phenomenon of heart rate reduction before throw was not observed in the present study. The muscular demands of the task in the present study, which resulted from holding the ball in the hands and static contractions in preparation for the throw, appeared to suppress any reduction in heart rate that would indicate tinnitus. The rapid and high increase in heart rate up to about 40 beats per minute in both expert and beginner groups is proof of this claim. The rapid return of heart rate in both groups after the throw is a type of relief from the task, which was observed 2 seconds after the throw. Because this cardiac pattern was observed in both groups, the interpretation is that it is dependent on task performance, not skill level. The claim of Tremin and Berry (2001) who attributed this pattern to the skill level was not confirmed in the task of this research. Heart rate was higher in good throws than in bad throws, both before and after. However, the pattern of heart rate changes in the two types of throws was not different.

The interpretation of the findings is that arousal/activation effects (as measured by SCL) are dissociated from attentional effects (as measured by heart rate) based on their differential involvement in discriminating good from bad throws. This interpretation is supported by the poor correlation of skin and cardiac response profiles in good and bad throws of the skilled group. It cannot be defended that these two scales measure a single structure. The possible interaction of these two systems is beyond the scope of the present research, however, it is an interesting phenomenon that will be addressed in future research.

In summary, it is hypothesized that the electrical skin activity of the proficient group, which reflects their moment-to-moment state of arousal, provides a picture of a decrease in pre-throw arousal that is immediately followed by a jump to baseline and beyond. This profile may be a reflection of the stability of the body in the last seconds before the throw. This process itself does not appear to affect the performance outcome in the skilled group. However, a lower level of arousal prior to throwing may facilitate concentration. This claim can be confirmed by the higher jump of the ball after the throw, which shows more relief from the task.

Contrary to the findings of Tremin and Berry (2001), the cardiac data of the present study do not show a clear picture of the tinnitus condition. This is contrary to the prediction of attraction-rejection hypothesis. The underpinning of the attraction-rejection hypothesis points out that the attraction of the stimulus is associated with inactivating or reducing the heart rate and the rejection of the stimulus is associated with activating or increasing the heart rate (Lacey, 1967). The internal afferent feedback model presented by Lisi and Lisi (Lacey & Lacey, 1974, Lacey & Lacey, 1980) completed the absorption-rejection hypothesis in such a way that reducing the heart rate by reducing the inhibitory effect of the medulla in the cortex facilitates the processing of external stimuli (Hatfield, Landers & Ray, 1987).

Thus, it was expected that the alertness of the throwers of this study should be associated with a decrease in heart rate; but no significant decrease in heart rate was observed. Therefore, the harmony of the cardiac findings of the present research is more with the proposal of Abrist (Obrist, 1981) who emphasized the physical component of heart rate reduction. He claimed that the decrease in heart rate is not directly related to attention, but the indirect effect is the decrease in motor activity. Bronia (1984)



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also mentioned that changes in muscle activity will make the findings not support the hypothesis of heart-body connection. Apart from shooters (Tremayne & Barry, 1990 & Tremayne & Barry, 2001), heart rate reduction was previously observed in beginner and expert archers (Wang & Landers, 1986), it seems that the findings of the present research have clarified the role of task type in the pattern of heart rate changes. Both archery and shooting tasks involve posture stabilization, aiming, breath holding, firing/releasing, and movement sequences, which likely play a role in the occurrence of similar patterns of heart rate changes. On the other hand, basketball free throws do not involve stabilizing the position and holding one's breath in the way shooting and archery do. In this way, the findings of the present research, while confirming the functional difference of skin electricity from heart rate, consider SCL as an indicator of changes in arousal and heart rate as related to the physical variables of the task. Heart rate appears to show ringing effects only when the perceptual/cognitive demands of the task exceed its muscular demands.

Considering that the present study is the first step in Tremin and Barry's (2001) research path that examines the pattern of physiological changes in a sports skill, the attribution of the different findings of this study is considered premature only to physical demands. It seems that in future researches, the attention demands of the task should be taken into consideration as much as its muscular demands.

The findings of this research help to clarify the complex perceptual/cognitive processes in basketball free throws and show the usefulness of the psychophysiological perspective in sports psychology.



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# الگوی فیزیولوژیکی پرتاب های آزاد بسکتبال

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**چکیده:** : چند ثانیه قبل از یک رویداد مورد انتظار، کاهش سیستماتیک ضربان قلب (HR) مشاهده می شود که منعکس کننده پردازش توجه است. با این حال، تغییرات برانگیختگی، تفسیر این کاهش را مهار می‌کند. پژوهش حاضر با هدف بررسی اثرات هوشیاری و برانگیختگی حین اجرای ماهرانه به صورت جداگانه و با استفاده از معیارهای جداگانه برای دو حالت روانشناختی انجام شد. HR و سطح هدایت پوست (SCL) به عنوان شاخصی از هوشیاری و برانگیختگی ۱۸ نخبه و ۱۹ مبتدی در طی ۳۰ پرتاب آزاد بسکتبال به صورت خود-آغاز و خود-آهنگ اندازه گیری شد. مقادیر HR و SCL در فواصل نیم ثانیه از ۱۰ ثانیه قبل تا ۱۰ ثانیه پس از هر ضربه محاسبه و با آنوا با اندازه گیری مکرر تحلیل شد. در نخبگان، SCL قبل از پرتاب کاهش آهسته و پس از آن افزایش بلافاصله و سریع داشت. در مقایسهٔ پرتاب‌های خوب با بد، یافته های مشابهی پیدا شد. هر دو تغییر در مبتدیان کمتر بود. مقدار بازگشت SCL پس از ضربات خوب به ۸ برابر بیشتر از مقدار قبل از پرتاب رسید. افزایشی شدید در HR، تا ۴۰ ضربه در دقیقه، چهار ثانیه قبل از پرتاب مشاهده شد، که پس از ۲ ثانیه برای نخبگان به مقدار قبل از شلیک بازگشت. این تغییر در مبتدیان دیده نشد. HR در پرتاب‌های بد بیشتر از پرتاب‌های خوب بود. نتایج نشان داد که SCL در زمان انجام کار و الگوی تغییرات آن نشان‌دهنده سطح مهارت است. اگرچه، HR در پرتاب‌های خوب کمتر بود، الگوی تنوع در HR الزامات فیزیکی کار را منعکس کرد. نتایج با یافته‌های قبلی مقایسه شد و در رابطه با فرضیه‌های تبیین برانگیختگی و هوشیاری در عملکرد انسان مورد بحث قرار گرفت.

واژه‌های کلیدی: سطح هدایت پوست، برانگیختگی، ضربان قلب، هوشیاری، پرتاب آزاد بسکتبال، فیزیولوژی روانی.

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