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Stress related changes during TeamGym competition

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Abstract

Aim: The aim of the present study was to investigate the stress-related changes of a TeamGym competition considering both physiological [i.e. salivary cortisol (sC) and alpha-amylase (sA-A)] and psychological (i.e. state anxiety) responses in relation to exercise intensity and competition outcomes. **Methods:** Eleven (5 males and 6 females) elite TeamGym athletes (age: 21-28 yrs) were administered the State-Trait Anxiety Inventory before an official international TeamGym competition. sA-A and sC samples were collected 15 minutes prior to competition, after each apparatus, 10-min and 30-min after competition. Exercise intensity was estimated by heart rate (HR) recording and performance was evaluated by three international judges. All these parameters were correlated with competition outcomes. **Results:** TeamGym competition posed a low exercise load (most of exercise was performed below 85% of the individual HR_{max}). Significant increases ($P<0.004$) in sA-A (3.53 fold induction) and state anxiety ($P=0.045$) were observed, with respect to baseline values. Conversely, sC remained stable throughout the competition. Significant ($P=0.029$) correlation between sA-A, state anxiety and competition outcomes emerged. **Conclusions:** Present findings provide the first evidence that the psycho-physiological stress response prior to and during competition can affect performance outcome, especially in a technical sport such as TeamGym.

Key-words: Performance, state anxiety, salivary alpha amylase, salivary cortisol, heart rate

INTRODUCTION

TeamGym is a popular form of gymnastics with 6-12 members in each team simultaneously performing three different events: trampette, tumbling and floor exercises. In trampette and tumbling competitions, teams have to perform three series of acrobatic elements within a 2.45-min routine; the floor program consists of approximately a 3-min choreographic exercise.[1] The final score of each apparatus is assigned for the team by the mean of each individual performance. The difficulty in performing the required skills, the public display of skills, the pressures and expectations to perform, the nature of the event, and the competition level pose a high physical and psychological load on athletes.[2] To accurately describe the competition stress-related responses of athletes, multiple physiological and psychological variables should be assessed. In particular, studies on the physiological response to competitive stress focused on heart rate (HR) and hormonal responses.

Temporary changes in salivary alpha-amylase (sA-A) and cortisol (sC) concentrations have been reported during competitions [3, 4, 5] of different sports, but there is a paucity of studies in TeamGym and gymnastics. The sympathetic adrenomedullary system (SAM) with the secretion of catecholamines, [6] and the hypothalamic pituitary adrenocortical system (HPA) with the secretion of cortisol, [7] have been used as objective markers of stress. [8, 9] In order to be able to measure the stress response to competition, non invasive methods need to be used. In contrast to cortisol, the measurement of catecholamines in saliva is more problematic [10] and their levels do not parallel those in plasma.[11] Recently, sA-A has been proposed as a surrogate marker of the SAM activity via adrenergic receptors [6] and studies showed that this enzyme increases under both physically and psychologically stressful conditions.[12]

In addition to physiological assessment, psychological measures offer a unique possibility to accomplish a more comprehensive evaluation of the stressful demands of performance; [13,14] a common psychological index of stress in sport is anxiety. [15, 13, 16] Whereas literature highlights

evidence between sA-A levels and anxiety, [10, 17, 18] controversial findings emerged between sC and this emotional state.[18, 19, 13, 14, 16] Despite scientific evidence on elite athletes' psycho-physiological responses and competition outcome is often controversial [14, 3] a relationship between athletes' level of expertise and their stress performance responses has been hypothesized. [12, 20]

Protocols involving simulated situations could underestimate stress-related response of athletes to high competitive conditions. [21] Because no previous study examined the stress-related response of athletes during TeamGym competitions, the aim of the present study was to apply an integrated psycho-physiological approach to the measurement of stress during the most important TeamGym competition (European Championship). In particular, it was our intent to relate the stress response to the competition outcome. Based on theoretical propositions, it has been hypothesized that: 1) TeamGym competitions would impose a heavy psycho-physiological load on athletes; 2) the two major systems involved in responses to stress (i.e. SAM and HPA) would react differently to competition; 3) the psychological (i.e. state anxiety) and physiological (i.e. HR, sC and sA-A concentrations) responses to competitive stress would be related; and 4) the psycho-physiological response to stress may mirror competition outcomes.

METHODS

Study design

The protocol employed was approved by the local ethical committee. Written consent was obtained from athletes who agreed to participate in this study.

Three experimental sessions (i.e., laboratory, during competition, and during a rest day) were scheduled. According to the literature [22] exercise intensity during official competition has been evaluated by means of individual HR responses expressed as percentage of athlete's HR_{max}. Thus, in the first experimental session athlete's HR_{max} has been determined by means of a laboratory incremental treadmill test to exhaustion. Furthermore, to evaluate the biohumoral responses (i.e., sC and sA-A) to competition stress, the percent difference between concentrations measured in competition (second experimental session) and during time matched resting values (third

experimental session) was calculated. [20, 4] Furthermore, to investigate the psychological stress-related responses of athletes to competition, the individual's feeling of anxiety was measured by means of the Italian version of the State-Trait Anxiety Inventory (STAI-Y). In particular, to evaluate the state anxiety relative to the actual competitive situation, [22] the STAI-Y1 form was administered 15 minutes prior to the beginning of the competition. Furthermore, the state anxiety values were expressed in relation to the individual's general and baseline tendency to be upset in stressful situations (i.e., trait anxiety), evaluated during the laboratory session by means of the STAI-Y2 form. In considering that TeamGym outcomes refer to as the whole team and no individual performance scores are visible in competition, to evaluate the individual performances at each apparatus, three international judges' assigned penalties to each athlete by means of video analysis. Moreover, inter-judges variability has been verified.

Participants

The minimum number of participants required was determined by an a priori power analysis.[23] Power was fixed at .80, alpha at .05 and effect size at .35. Furthermore, to prevent potential contaminating effects of the athletes' ability level and previous experiences, to be included in this study the participants had to: 1) belong to the same team; 2) have won the same year the Italian Championship with the same program. Thus, five elite male (age:27±2yrs, height:1.70±0.3m; BMI:23±1kg·m^{-2}; $VO2_{peak}$:50±6ml·kg^{-1}·min^{-1}; HR_{max}:195±6beat·min^{-1}) and six elite female (age:24±2yrs, height:1.62±0.3m; BMI:21±1kg·m^{-2}; $VO2_{peak}$:43±7ml·kg^{-1}·min^{-1}; HR_{max}:193 ±7beat·min^{-1}) members of the University TeamGym were selected. They all had at least 5 years of previous training, and participated in the European Championship.

Testing Procedures Determination of anthropometric and physical parameters.

Two weeks prior to the competition TeamGym athletes performed an incremental treadmill test to exhaustion to determine their maximal oxygen uptake ($VO_{2\ max}$), maximal HR (HR_{max}). Before starting the test body mass and height were measured. All subjects were familiarised with treadmill running before performing the graded incremental test. After 5-min warm up, maintaining a 0°

slope, a 1 km/h speed increment was applied every minute, starting from 9 km/h [24] Cardiac, respiratory and metabolic parameters were assessed by Quark b^2 (Cosmed, Rome, Italy) and the individual VO_{2max} was identified by the occurrence of one of the following criteria: (a) a plateau or an increase less than 1 ml/kg/min of VO_2 despite further increases in the exercise intensity; or (b) a respiratory gas exchange ratio higher than 1.1. In case the test ended before the attainment of the VO_{2max}, the VO_{2peak} was calculated averaging the final 30 s values of the exercise test.

Competition load

With a 5-s sampling, a HR transmitting belt (Team System, Polar, Kempele, Finland) placed on the athlete's chest under the leotard recorded the athlete's responses during the competition. To indicate the physical load, HR recordings were expressed as percentages of the athlete's HR_{max} by means of three intensity categories: (a) maximal effort (>95% HR_{max}); (b) high intensity (85–95% HR_{max}); (c) low intensity (<85% HR_{max}). The percentage of time (s) spent in each activity category was calculated.

Saliva collection and assays

Stress related markers (i.e. sA-A and sC) were measured 15 minutes prior to the beginning of the competition (pre-competition), immediately after the end of each apparatus (post-tumbling, post-trampette, post-floor) performance (scheduled with a 30-minute cadence), and at 10- and 30-min of post-competition recovery phase. The same time schedule was used to collect salivary samples during a recovery day scheduled seven days after the competition. In considering that the European team competition was scheduled between 1200h and 1400h, effects of circadian rhythm of sC [7] and sA-A [25] were controlled. Cotton swabs and saliva collecting tubes (Salivette, Sarstedt, Germany) were used to obtain saliva samples (>0.05 µl); athletes were fasted and instructed to place the cotton swab into their mouth for 2 min and to chew 20 times. After ascertainment of salivary blood contamination absence, saliva samples were centrifuged at 3000 rev·min^{-1} for 15 min at 4 °C, stored at –80 °C, and assayed in the same series to avoid inter-test variations. An enzyme immunoassay kit was used to measure sC concentrations and a kinetic reaction assay kit was used

for sA-A measurements, respectively (Salimetrics LLC, State College, PA, USA), according to manufacturers' instructions.

Psychological measures

The Italian version of the STAI-Y [26] was used to evaluate the athletes' state anxiety, which comprises two separate 20-item, self-report rating scales for measuring state (STAI-Y1) and trait anxiety (STAI-Y2), with a total score ranging from 20 to 80 points, respectively. The items for the STAI-Y1 scale require a respondent to describe the intensity of a feeling in a particular moment using a 4-point scale, ranging from not at all (1 point) and very much (4 points). The STAI-Y2 scale probes how a respondent generally feels by rating the frequency of his/her feelings on a 4-point scale, ranging from almost never (1 point) and almost always (4 points). This instrument showed a high reliability (Cronbach's alpha = 0.83 for the Y2 form, and 0.94 for the Y1 form).

Competition outcomes

During official TeamGym competitions scores are given to the team, therefore no individual scores are available. Thus, three national TeamGym judges evaluated recordings (Panasonic NV-DS1-EG) of each athlete's performance. Final score was obtained considering that inter-judge differences, according to the TeamGym Code of Points. [1]

Statistical analyses

Data are presented as mean ± SD. After defining a .05 level of significance data analyses were conducted using the Statistical Package for the Social Science, version 18.0 (SPSS, Chicago, IL). Prior of the study Kolmogorov test was applied to test the normal distribution of the data. The analysis of variance for repeated measures (sampling: pre-competition, post-tumbling, post-trampette, post-floor, 10-min and 30-min recovery) was applied to sA-A and sC values, with post hoc Fisher's protected least significant difference (PLSD) comparisons. Paired sample t-test analysis was applied to verify sA-A and sC values differences between competition and resting day and between apparatuses. The relationships between variables were estimated using Pearson

product-moment correlation, coefficient of determination (r = correlation coefficient; R^2 = coefficient of determination), and 95% confidence interval (95% C.I.).

RESULTS

No gender differences emerged in the analyzed variables; therefore data were pooled together for further analysis. Floor exercise elicited higher HR responses (182± 10beat·min^{-1}) with respect to tumbling (159±16beat·min^{-1}) and trampette (153±17beat·min^{-1}) competitions, with differences (P<0.01) emerging only for low intensity and maximal effort categories (Figure 1).

Insert Figure 1 around here

State anxiety measured prior to competition showed significantly (P=0.045) higher values (50.67±9pts) than trait anxiety (40.25±3 pts).

With the exception of the 30-min post-exercise time point, Pre-competition and competition sA-A levels were significantly higher compared to time matched resting samples (P ranging between 0.004 and 0.001). sAA concentrations increased significantly after tumbling, trampette and floor exercise (P ranging between 0.005 and 0.0001). These values significantly decreased only at the 30-min post-competition time point, falling to baseline pre-competition concentrations (Figure 2). The sC values did not change with exercise and no difference was observed with time matched resting samples (Figure 3).

Insert Figures 2 and 3 around here

A significant correlation was found between the pre-competition s-AA concentrations and pre competitive state anxiety (r= 0.80; r^2= 0.64; 95%C.I. = 0.344-0.95; P= 0.029). Assigned penalties were significantly related to maximal class of effort during tumbling performance (r= 0.793; r^2=

0.63; 95%C.I.=0.327-0.948; P= 0.019), and during trampette performance to state anxiety (r= 0.861; r^2= 0.74; 95%C.I.=0.506-0.966; P= 0.006). Correlation coefficients among variables in each apparatus are shown in Tables 1, 2, 3.

Insert Tables 1, 2, 3 around here

DISCUSSION

The present study evaluated the interaction of anxiety and physical stress in relation to competition outcomes during European TeamGym competition utilizing the evaluation of physiological (i.e., cardiac load) psychological (i.e., state anxiety) and neuroendocrine (i.e., sC and sA-A) aspects. The main findings of this study were 1) competition posed a low load and a high level of psycho-physiological stress, independently from gender; 2) the SAM and the HPA axis reacted differently to stressful demands of competition with significant increases of sA-A levels prior to and during competition with respect to baseline concentrations, while sC did not change; 3) pre competition anxiety and sA-A concentrations were significantly correlated and explained performance outcome. To our knowledge, this is the first study that shows a relationship between the psycho-physiological responses (i.e. HR, state anxiety and sA-A) and competition outcomes for highly technical sports.

Tumbling and trampette performances of the TeamGym competition showed lower exercise intensities with respect to findings in elite artistic gymnasts. [27] On average, athletes performed acrobatic tumbling and trampette routines spending around 62% of the time exercising below 85% of $HR_{max.}$ Conversely, floor exercise elicited very high HR responses: on average, athletes performed 68% of time exercising at intensities >95% of their $HR_{max.}$ Differences in exercises intensity are due to the different nature of the apparatus competitions. While tumbling and trampette

trials require few seconds of very high intensity work, followed by long resting periods due to the round executions, floor performance is a 3-min continuous, pressing and vigorous exercise.

When considering athletes' state anxiety and physiological responses, TeamGym competition seems to induce a high level of psycho-physiological stress. In fact, although state anxiety remained close to average levels, it significantly increased with respect to trait anxiety, suggesting a perceived threatening psychological state during competition due to its challenging nature. Previous studies on gymnasts in fact highlighted that this is a sport with a high level of unpredictability and therefore induces high levels of stress and anxiety. [15] Anxiety and physiological responses (i.e., HR and skin conductance) have been shown to be high already during an imagery session of their competition in a population of gymnasts.[28] Despite the fact that competition is generally recognized as a more challenging and threatening situation compared to training [21] Cottyn and colleagues [29] did not find differences in the anxiety scores reported by the gymnasts during training or competition. Heart rate instead showed much higher values during competition.

Regarding s-AA, it has been proven that it is a sensitive marker of mild psychological and physical stress even during competition [20] and an indirect predictor of sympathetic reactivity, [30, 6] since the norepinephrine release is responsible of sA-A secretion by the salivary glands. Only a few studies are available regarding the s-AA response to [12, 20, 5] and prior to [9, 12, , 5] competition. In the present study, pre-competition sA-A significantly increased by 1.12 fold induction, compared to time-matched baseline; the peak value (3.53 fold induction of the time-matched baseline) was found immediately after the floor exercise, the last apparatus and fell to pre-competition levels 30 minutes after. Kivlighan and Granger[12] instead, found changes in s-AA only to and not in anticipation of an indoor rowing competition. Similarly to our results, sA-A concentrations were significantly higher in skydivers on the morning of the jump compared to a non-skydiving control group. However, compared to their own control resting values, sA-A levels did not differ with what found the morning of the jump.[9] Most probably the typology of the competition and the risk involved might determine an anticipatory psychological stressor beforehand, so that athletes respond

physiologically with a rise in sA-A. Peak concentrations were observed at the end of the competition, immediately after performance, similarly to what already seen in taekwondo competitors[20] in female rowers. [12] and in master runners during a half marathon.[5] In our study, peak sA-A values were observed at the end of the competition and decreased toward resting values after 30 minutes of recovery. This fast sA-A recovery is not in line with what previously reported in rowers,[12] or runners [5] but very similar to what observed after a youth taekwondo competition[20] or skydivers.[9] Similarly to taekwondo, the intermittent nature of the event with long resting periods might have a positive impact on the recovery process, determining a faster return to baseline values.

In conclusion, since sA-A can be surely considered a marker of the SAM reactivity to stress conditions, [8, 30] high concentrations of this enzyme during TeamGym competition sustain the athletes' high psycho-physiological loads. On the contrary, in the present study sC concentrations showed no significant changes prior to or during exercise. Our findings are not in line with a previous study performed on gymnasts that found an increase by 20%, 81%, and 37% in sC concentrations after moderate and intensive training sessions, and competition, respectively.[21] The athletes' age and the competition apparatus differences can explain the discrepancy in the results. Despite many studies showed increased cortisol concentrations in response to competition in several sports, [13, 17, 20, 5] there are some possible reasons that can help to explain why we found no effect of TeamGym on cortisol. First of all, literature highlighted that significant increases in sC concentrations occur in response either to long-duration such as golf [16] and half marathon,[5] or if the exercise intensity is above a certain threshold such as judo,[17] paragliding,[13] and taekwondo.[20] Thus, the short-duration bouts of intermittent nature of TeamGym performance could have permitted recovery between apparatuses; in our case athletes performed each apparatus with 30 minutes of recovery in between, and for tumbling and trampette routines the effort lasted approximately 3 minutes with several seconds of recovery between one round and the other. Unfortunally the competition rules didn't allow to collect salivary samples at the end of each acrobatic round. Thus,

senior athletes' amount of work was probably too low to induce an appreciable HPA axis response.[17]

Both the lack of relationship between sC and sA-A and their different responses to stressful competitions suggest differential functions for the two major stress response systems, especially during moderate intensity exercise. [6]

The SAM activity may be specifically related to the mobilization of effort in situations perceived as controllable and would occur to challenges that are milder than those required to activate the HPA axis; [12] this would also suggest that salivary enzyme released in response to competition would be greatest in the most competent and experienced competitors. In conclusion, our findings and literature suggestions seem to indicate that sA-A could be considered a better indicator of acute stress than cortisol, [10] especially in elite adult gymnasts. Physiological responses to stress were only partially related to athletes' psychological state during competition: in tumbling and floor performances the psycho-physiological measurements of stress (i.e. state anxiety, sA-A and HR) are closely related. No correlation was found with cortisol levels. In particular sA-A concentration was positively related to pre-competition state anxiety, and to the maximal class of effort during tumbling and floor exercises. Our results seem to confirm the hypothesis of Chatterton and colleagues[8] **(1996)** assuming that sA-A secretion responded proportionally less to the low intensity, but more to the higher intensity stimulus than HR. Furthermore, these data seem to confirm that sA-A is sensitive both to physical and psychological stress;[30] **(Nater et al., 2005);** in tumbling performance, although HR indicated moderate physical load, sA-A significantly increased in relation to state anxiety, indicating to be more sensitive to psychological stress. As indicated by sA-A pre-activation, athletes perceived the competition as a stressful event; furthermore, their high anxious states could be explained by the high technical difficulties scheduled for this apparatus, and by the fact that it was the first to be performed: in our experience, the first apparatus outcome can affect athletes' entire competition. On the contrary, during floor performance the sA-A concentrations seem to be related more to the physical demands than to the psychological ones; in

fact, not only the HR indicated a heavy internal load, but it is not perceived as threatening by athletes. Anxiety scores proved to correlate with sA-A, suggesting that the SAM activity is more sensible to the psychological variations during competition than the HPA axis.[10] In the effort to clarify the relationship between HPA stress response and personal traits, anxiety components[14] (somatic and cognitive anxiety, and self-confidence) and anxiety direction[15] have been investigated; unfortunately results are still controversial.[19, 16]

Finally, competition outcomes measured by judges' penalties during acrobatic executions, were related to state anxiety levels in trampette competition and to the highest HR during tumbling rounds. Our findings seem to indicate that high psycho-physiological responses to stress can be detrimental for competition results, probably because they lead to distractibility and attentive focus disorders. Lower sympathetic reactivity, instead, has been shown to facilitate both physical and mental performance, when the induction of the stress response is not too great.[12] Future studies are needed to verify this hypothesis.

Our findings have several noteworthy limitations: since this study was conducted during a real competition performed by elite adult athletes, it was impossible to include a larger number of subjects. Another limitation of the present study was the lack of investigation of the relationship between physiological responses and level of performed acrobatic skills. In fact, as the level of psycho-physiological response and performance is affected by practice, skill and previous experiences[12] future research should assess the impact of different levels of competition (national vs. international) and expertise (elite vs. non-elite).

CONCLUSIONS

This study is the first attempt to provide understanding athletes' psycho-physiological responses to an official TeamGym competition. Stress markers reacted differently: while sC remained stable, the sAA increases related to anxiety levels could explain the athletes' competition

activation and outcomes. Athletes' responses to a competition could indicate to coaches and psychologists future interventions program to facilitate both physical and mental performance.

Although the strict criteria for inclusion, not only might have affected the statistical significance of some results, but also restrict their generalizability, the present findings provide the first evidence that the psycho-physiological stress response prior to and during competition can affect performance outcome, especially in a technical sport such as TeamGym. TeamGym was chosen because it is a risky sport: further research could better explain the role of arousal in determining competition outcomes especially in those sports in which steadiness, precision and control are required.

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Table 1: Correlation coefficients relative to State Anxiety, salivary alpha-amylase (sA-A), salivary cortisol (sC), heart rate (HR>95% and HR 85-95%) and penalties, during European Tumbling performance.
*denotes significant correlation ($p<0.05$)
** denotes significant correlation ($p<0.01$)

Table 2: Correlation coefficients relative to State Anxiety, salivary alpha-amylase (sA-A), salivary cortisol (sC), heart rate (HR>95% and HR 85-95%) and penalties, during European Trampette performance.
** denotes significant correlation ($p<0.01$)

Table 3: Correlation coefficients relative to State Anxiety, salivary alpha-amylase (sA-A), salivary cortisol (sC), heart rate (HR>95% and HR 85-95%), during European Floor performance.
** denotes significant correlation ($p<0.01$)

Figure 1: Percentage of occurrences of athletes' heart rate frequencies at three apparatus during European competition.
* denotes a significant difference between floor and tumbling and trampette values ($p<0.01$)

Figure 2: Mean ± SD Alpha-amylase concentrations during European competition and during rest time.
* denotes a significant difference between pre-competition and competition values ($p<0.01$)
# denotes a significant difference between competition and time marched rest resting samples ($p<0.01$)

Figure 3: Mean ± SD Salivary Cortisol concentration during European competition and during rest time.

Table 1 Correlations between state anxiety, sA-A, sC, heart rate frequencies (HR>95% and HR 85-95%) and penalties, during European Tumbling performance

	Tumbling					
	State Anxiety	**sA-A**	**Cortisol**	**HR>95%**	**HR 85-95%**	**Penalties**
State Anxiety	1	.387 (p=.214)	.535 (p=.070)	.743 (p=.009)	.611 (p=.081)	.037 (p= 0.938)
sA-A		1	.539 (p=.070)	.711 (p=.021)	.320 (p=.401)	.291 (p= 0.757)
Cortisol			1	.337 (p=.375)	.116 (p=.767)	.222 (p=.597)
HR>95%				1	.385 (p=.306)	.793 (p= 0.019)
HR 85-95%					1	
Penalties						1

Table 2 Correlations between state anxiety, sA-A, sC, heart rate frequencies (HR>95% and HR 85-95%) and penalties, during European Trampette performance

	Trampette					
	State Anxiety	**sA-A**	**Cortisol**	**HR>95%**	**HR 85-95%**	**Penalties**
State Anxiety	1	.255 (p=.423)	.197 (p=.540)	.018 (p=.967)	.229 (p=.585)	.861 (p= 0.006)*
sA-A		1	.536 (p=.073)	.358 (p=.383)	.403 (p=.322)	.612 (p= 0.197)
Cortisol			1	.470 (p=.240)	.171 (p=.685)	.555 (p=.154)
HR>95%				1	.345 (p=.402)	.169 (p= 0.680)
HR 85-95%					1	.351 (p=.394)
Penalties						1

Table 3 Correlations between state anxiety, sA-A, sC, heart rate frequencies (HR>95% and HR 85-95%), during European Floor performance

Floor					
	State Anxiety	**sA-A**	**Cortisol**	**HR>95%**	**HR 85-95%**
State Anxiety	1	.360 (p=.250)	.137 (p=.672)	.038 (p=.916)	.432 (p=.212)
sA-A		1	.409 (p=.187)	.927 (p=.001)*	.193 (p=.593)
Cortisol			1	.120 (p=.741)	.175 (P=.629)
HR>95%				1	.535 (p=.111)
HR 85-95%					1

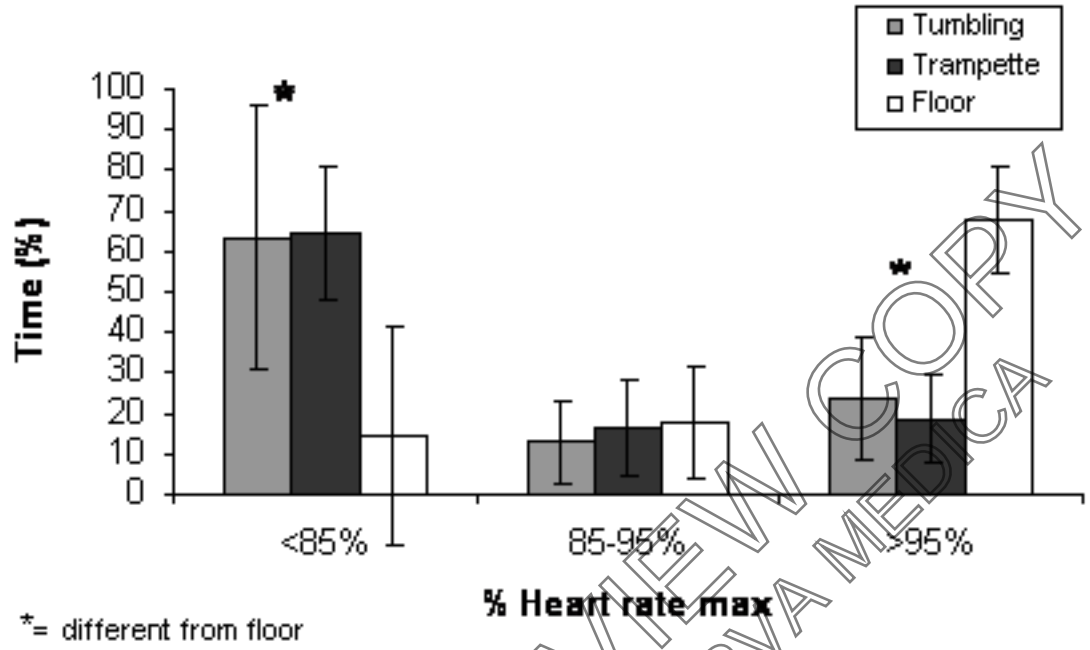
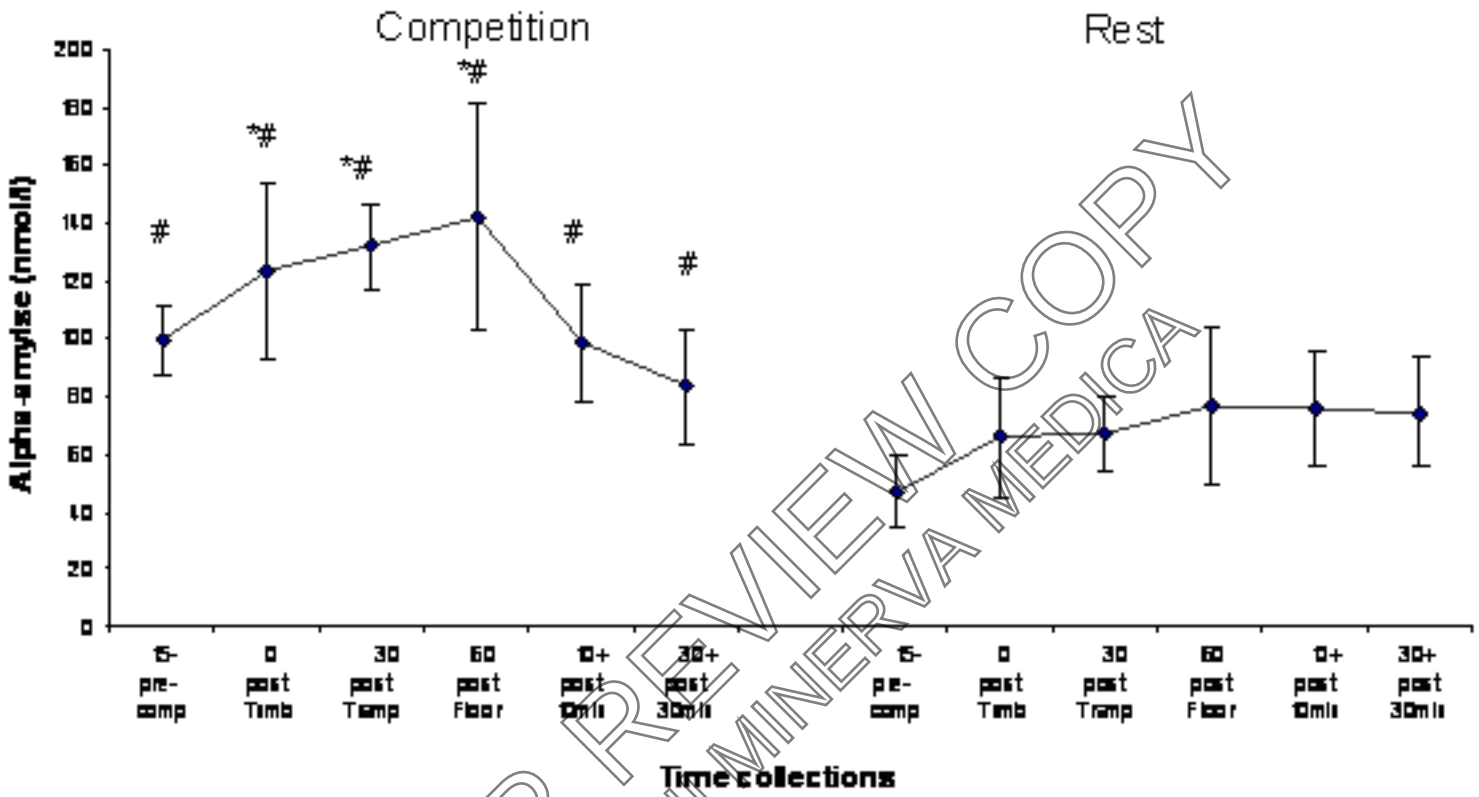


Figure 1- Percentage of occurrences of athletes' heart rate frequencies at three apparatus during European competition.



* Significant difference between pre-competition and competition values (P<0.01)
\# Significant difference between competition and time marched rest resting samples (P<0.01)

Figure 2- Mean ± SD alpha-amylase concentrations during European competition and during rest time

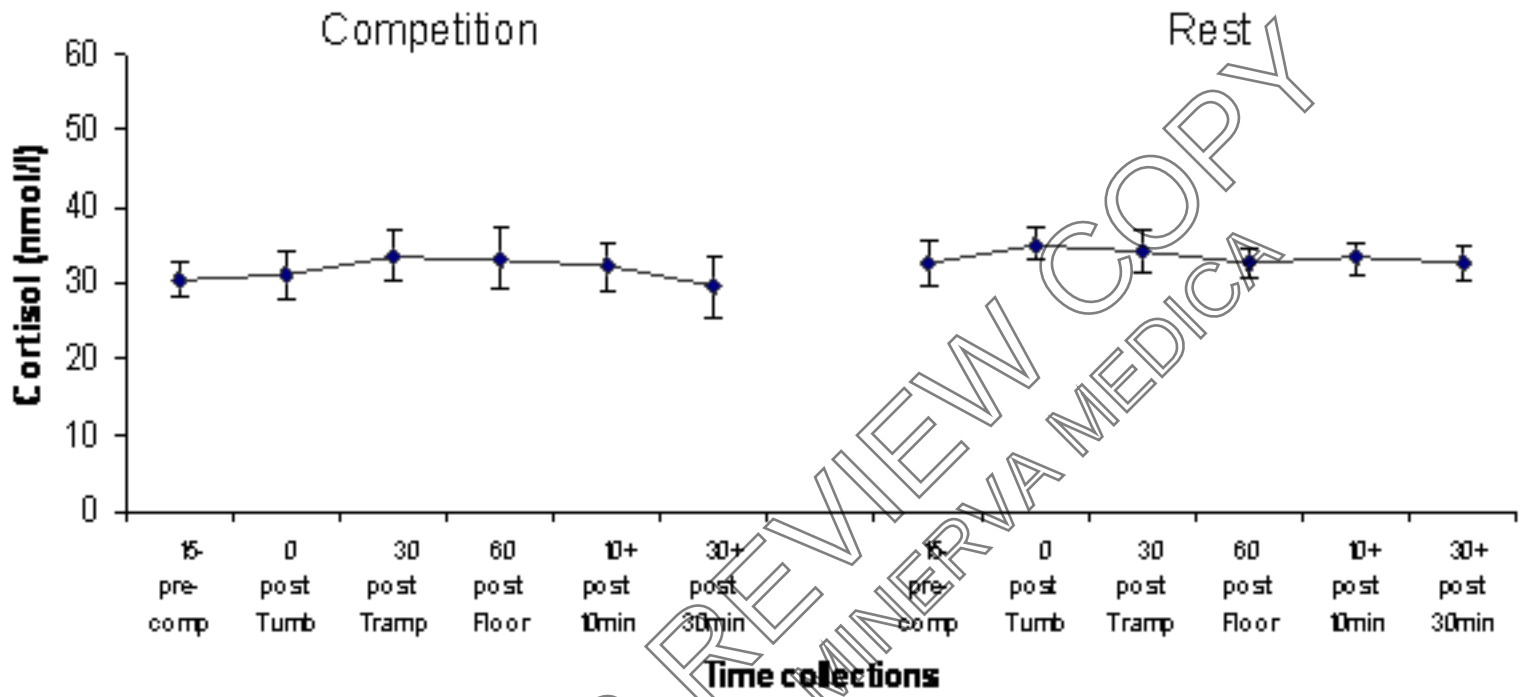


Figure 3- Mean ± SD Salivary Cortisol concentration during European competition and during rest time