Autonomic-Nervous-System Activity During the Preparation Phase for the Snatch in Olympic Weight Lifting

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Purpose: To examine the preparation phase for the snatch lift in Olympic weightlifting. Two behavioral periods were studied, each corresponding to specific mental processes: a stance in front of the bar and placement of hands on the bar. Each period was hypothesized to elicit different responses of autonomic-nervous-system activity. Methods: Twelve elite male subjects completed 12 lifts at 90% to 95% of their best grade after warm-up (80% of their best grade). Because peripheral autonomic-nervous-system activity is related to arousal and activation variation, 6 variables were continuously recorded: electrodermal (skin resistance and potential), thermovascular (skin temperature and skin blood flow), and cardiorespiratory (heart rate and respiratory frequency). Results: Responses (ie, phasic activities) were evident during the first behavioral period. Decrease in heart rate (mean = 19 beats/min) or in respiratory frequency (mean = 8.6 beats/min) was related to attention processes. These responses were weaker (–0.16°C vs –0.25°C in skin temperature) and shorter (2.7 seconds vs 4.3 seconds in skin resistance) than those recorded during execution. The second phase showed variations in basal levels (mean increase in heart rate of 25%), related to increase in activation, thus attesting the muscle system’s process of preparation for effort. Conclusion: Weightlifters separated the preparation phase into 2 stages that were closely matched by different physiological activities. Weightlifting requires participants to share their mental resources among the 2 demanding concentration phases by first focusing their attention on the execution and then mobilizing energizing resources.

Key Words: exercise performance, sport psychology, neuroscience, motor behavior, attention, activation

The preparation for a motor action is one of the more critical phases to ensure a successful result, particularly in sporting activities requiring maximal intensity during a very short period of time. During this preparation phase, athletes are supposed to increase their activation to an optimal level and focus their attention on...
several sequences of the movement they need to consciously monitor. In one study, participants then performed final adjustments of their activation/attentional set. Activation is defined as a set of processes required to improve a person’s aptitude for processing information and carrying out an action.

According to Näätänen, “intensive or energetic” preparation might be limited to physiological activation and energy mobilization. “Directional” preparation aims to orient sensorial systems to important cues needed to make the action successful. Directional preparation is often described as being vigilant, involving sustained readiness to detect and respond to environmental changes: It is an active, performance-related process, requiring perception of stimuli and information processing.

Boucsein integrates previous research in a model highlighting 3 different processes and their physiological-behavioral concomitants. Arousal system 1 is related to general activation (under the control of the reticular formation). Sensorial afferences are known to modulate reticular activity, which, in turn, adjusts central- and peripheral-nervous-system activities. When preparing for a motor act (arousal system 3), tonic activities of both somatic- and autonomic-nervous-system (ANS) effectors are increased simultaneously through reticulospinal pathways (eg, muscles and cutaneous blood vessels). Arousal system 2 is the affective activation system responsible for focusing attention on cues that have previously been memorized because of their high emotional load (recognition process). A set of peripheral responses is thus elicited via the hypothalamic pathways (eg, orienting response at the behavioral level, associated with autonomic responses). Thus, studying the resulting peripheral modifications related to activation during the preparatory period of action might help highlight the dynamic psychological processes involved in the preparation for intense exertion.

ANS activity is related to physiological changes occurring during “intensive and directional” movement preparation. Tonic activity (slow variation) is related to changes in activation level. Phasic activity is recorded in response to various stimuli, either exteroceptive or elicited by mental operations such as motor imagery. Finally, ANS is shown to reflect central-nervous-system operations at a peripheral level: A motor action is simultaneously programmed by central and autonomic nervous structures. ANS-activity analysis is thus a reliable method of studying mental processes preceding motor execution.

To perform the snatch lift, the weight lifter must raise the bar from the ground in a single movement while bending his legs. The athlete first lifts the barbell, then bends under the bar and raises it while straightening. To achieve this movement successfully, the athlete’s legs and arms must be fully extended. Before performing the movement, however, the weight lifter goes through a preparatory phase. First, as he is called onto the stage he goes automatically through the usual steps that remain specific to each athlete (eg, spreading resin on his shoes and rubbing magnesia on his hands). The athlete then stands upright in front of the bar. The second stage begins as soon as he places his hands on the bar. This bending position is maintained for a few seconds.

The main purpose of this experiment is to determine whether the 2 behavioral phases in the weight-lifting snatch are linked to directional or intensive preparations. The prelifting period (up to 1 minute) is thought to have 2 main functions:
• Recalling movement characteristics through mental phases such as recovering sensations of execution (sensorial phase). According to Posner,\(^{14}\) attentional resources facilitate the input stages of information processing (perceptual and decisional stages) without any regard to the motor components of the task. It thus should be related to directional preparation and elicit phasic autonomic responses.

• Increasing physiological activation, that is, mobilizing energy (motor phase). Activation facilitates the output of information processing (motor stages) without any regard to the perceptual components of the task.\(^{15}\) It thus should be related to intensive preparation and elicit tonic autonomic variations. Both processes are required for efficient movement.

Method

Subjects

Twelve elite male weight lifters between 17 and 25 years of age voluntarily took part in the experiment and signed an informed-consent form. Ethical approval from our university ethics committee and from weight-lifting trainers was obtained before the experiment. Based on self-reports, all subjects were free of any recent injuries that might have affected their performance. They were not informed of the theoretical questions of the study.

Design

The 12 weight lifters were asked to perform the first Olympic movement: the snatch. Each participant was tested while performing a series of 12 actual attempts. The load could vary from 80% to 95% of best grade. Trials were organized in 2 blocks, as follows: (1) 2 attempts at 80% and 2 attempts at 85% were considered a warm-up and were not taken into account, and (2) 4 attempts at 90% and 4 attempts at 95%, performed alternatively. Only the 90% and the 95% attempts were used for statistics. Each attempt was separated from the next by a period of rest at least 1 minute long, allowing participants to recover to their physiological baselines.

Methodology

Tonic variations were thought to evolve simultaneously with participants’ activation. Phasic activity and tonic variations were quantified with reference to 2 easily observable events: standing in front of the bar and hand-to-bar contact before actual lifting. Six ANS parameters were therefore selected to be continuously recorded: electrodermal (skin potential and resistance), thermovascular (skin blood flow and skin temperature), and cardiorespiratory parameters (instantaneous heart rate and respiratory frequency). Since multiparametric recordings through sensitive microsensors and new indices of ANS-activity quantification have highlighted new concepts on ANS physiological functioning,\(^{16}\) simultaneous and continuous measurements of ANS activity during motor preparation could lead to better understanding such mental processes.
**Skin Resistance.** Skin resistance was recorded using 30-mm² unpolarizable 
Ag/AgCl electrodes (Clark Electromedical Instruments, UK) placed on the non-
dominant forearm, held by adhesive tape. Skin resistance was measured with 15-μA 
DC current (current density = 0.5 μA/mm²). A new temporal index was defined, 
because response amplitude depends on prestimulation. Ohmic-perturbation duration 
is measured at the very beginning of the sudden drop, which occurs simultaneously 
with stimulus initiation. This response is followed by many fluctuations of a lower 
resistance level, compared with the tonic level before stimulation. Ohmic-perturbation 
duration ends when recovery shows no fluctuations, that is, when the slope resembles 
the one observed before stimulation. Concomitant observation of thermovascular 
indices enabled us to define the time during which the participant “responds” 
to stimuli, without referring to the initial value. The ohmic-perturbation duration 
reveals the emotional load of stimulation. To eliminate any interference between 
skin potential and resistance and other artifacts, parameters were recorded by means 
of a high-rate common rejection-mode differential “isolation” amplifier (Analog 
Devices AD 293 B). Likewise, the recorder’s inputs were in a differential mode, and 
resistance circuit supply was of the floating type. According to traditional recom-
endations, sensors are usually placed on the second phalanx of the second and 
third digits of the nondominant hand. In this particular case (ie, a bimanual task), 
the sensors were placed on the forearm near the wrist as shown in Figure 1.

Because of the digits’ common flexor tendon, sensors were placed on the equi-
distant line of the median plane and the inner extremity of the forearm. Sympathetic 
skin responses recorded from nonpalmar sites were demonstrated by Matsunaga et 
al to be correlated with those usually recorded from digits. Response amplitude

![Figure 1 — Sensor positioning. Weight lifting required placement of sensors on the forearm.](image-url)
was shown to be lower without affecting the general response pattern. Matsunaga et al.\cite{19} found that, although the density of sweat glands is higher on the palm than on the forearm, reproducible sympathetic skin responses were obtained from all recording sites. The conduction velocities of the postganglionic sympathetic nerve fibers forming the reflex pathways of the forearm were the same as the palmar sympathetic skin responses. Thus, latencies at the forearm were similar to those recorded on the palm.\cite{19}

**Skin Potential.** Skin potential was recorded using Beckman self-adhesive 78-mm² electrodes. As shown in Figure 1, skin-potential sensors were placed on the forearm. The active electrode was placed on the wrist of the participant’s nondominant hand after the skin was cleaned with ether alcohol. The reference electrode was placed 10 cm higher on the forearm. Because of the digits’ common flexor tendon, sensors were placed on the equidistant line of the median plane and the outer extremity of the forearm. Signal processing for electrodermal potential variations was carried out using the SYDER code,\cite{16} which is based on the classification of elementary responses according to their form: “A” form is a spike whose duration is less than 5 seconds, “B” form corresponds to a classical physiological response (a rapid onset followed by a slow offset), and “C” form is a response with a plateau.

**Superficial Skin Blood Flow.** Skin blood flow was assessed using the original Hematron patented sensor (Dittmar, C.N.R.S/A.N.V.A.R., 1985, patent 85 15932). The noninvasive sensor was placed on the forearm, with adhesive tape higher on the wrist, as shown in Figure 1. The transducer consisted of a disk 25 mm in diameter and 4 mm thick. The measuring surface in contact with the skin was made up of 2 parts: the reference area at the periphery of the disk and the measurement area at its center. The temperature difference between these 2 areas was measured using 16 thermocouple junctions. A very low-thermal-inertia flat heater was located in the central part of the disk. A proportional, integral, and derivative device controlled the heating power in order to maintain a constant temperature difference of 2°C between the central area and the periphery. The size and shape of the heater were designed so that a thermal field was induced in the capillary network. The power necessary to maintain the constant temperature difference depends on skin blood flow: Heat was transferred through the skin and washed out by the blood flow. Skin blood-flow variations were measured by the difference (positive or negative) between the prestimulation and poststimulation values expressed in mW · cm⁻¹ · °C⁻¹ and by the duration of the oscillation perturbation expressed in seconds.

**Superficial Skin Temperature.** Skin temperature was measured by a low-inertia thermistor (10 K3 MC D2 Betatherm). A 4-mm² sensor was placed on the wrist with noncaustic glue. The sensor was placed just between the thenar and hypothenar eminences. A phasic variation of less than 1 hundredth of a degree can be detected under such conditions, independently of the tonic evolution resulting from outside conditions. The amplitude variation was measured by the difference between the tonic temperature level and the phasic variation, using the disrupted slope of the graph. Skin-temperature responses ranged from 1 to 40 hundredths of a degree. The duration was measured from the phasic-response initiation to this disrupted slope on the graph. Sensor positioning is illustrated in Figure 1.
**Instantaneous Heart Rate.** Heart rate was recorded by 3 silver electrodes in the precordial position. The D2 derivation signal (the interval between 2 consecutive R waves) was processed and delivered in the form of instantaneous heart frequency. The smallest appreciable variation was 0.5 beats/min, and the calibrated scale ranged from 0 to 200 beats/min. Thus, the increase or decrease of heart-rate frequency was easily assessed, and the relationship between the stimulus impact and the instantaneous heart-rate response was established. Cardiac response was thus quantified by its amplitude, that is, the difference between the prestimulation level and the lower (or upper) value. The duration during which heart-rate basal activity was modified was also measured. A decrease in heart rate is interpreted as an increase in focused attention, whereas an increase in heart rate is interpreted as an index of mental processes during execution.

**Instantaneous Respiratory Frequency.** Respiratory frequency was recorded by a low-inertia thermistor (10 K3 MC D2 Betatherm) placed at the entrance of the left nostril with hypoallergenic adhesive tape. This thermistor was self-heated (several degrees above ambient temperature) by measurement of the underlying current (0.5 mA). Exhaled air cooled the thermistor in each respiratory cycle. The same signal processing used for heart rate was employed for recording instantaneous respiratory frequency. Once again, variability was clearly evidenced, and unlike instantaneous heart-rate response, respiratory-frequency variation was increased by different kinds of stimuli. With reference to heart-rate processing, the amplitude and duration of the responses were measured.

**Recording Apparatus.** The apparatus consisted of a YTSE 460 type BBC (Brown Boveri) 6-channel potentiometric DC recorder fitted with an event tracer and an automatic synchronization appliance, which cancels out temporal differences between the 6 markers.

**Statistical Analysis**

**Phasic Values.** Taking into account the number of participants, and because the distribution was thought not to be Gaussian, only nonparametric statistical tests were used. The Wilcoxon test was used to compare the ANS responses between the preparation and execution phases. Because a deceleration in heart rate and respiratory frequency was observed during the preparation phase and an acceleration of both indicators was recorded during the execution phase, a simple linear regression was performed. Because the decoding system of skin-potential responses (SYDER code) brought in nominal data—classification of skin-potential responses—according to the general pattern (no response, A, B, or C form), data could also be placed in contingency tables. The chi-square test was used to compare the frequency of the 4 outcomes with the expected frequency, that is, an equal proportion of the 4 outcomes.

**Tonic Values.** Because of great interparticipant variability in ANS baseline values, measurements were expressed through normalized data, that is, ratios: Values recorded when weight lifters began the snatch were divided by those recorded when they put their hands on the bar. Because decreased skin resistance, skin blood flow, and skin temperature are related to increasing activation level, these
physiological variables are expected to show a ratio lower than 1. In the same way, because increased skin potential, instantaneous heart rate, and respiratory frequency imply increasing activation, a ratio greater than 1 was expected in these physiological variables. Between hand-to-bar contact and lifting, the number of ratios showing activation or relaxation was taken into account. Here again, the chi-square test was used.

Results

Phasic responses were mainly observed during the first phase, that is, from being called until hand-to-bar contact. Then these responses were compared with those recorded during the execution phase. Tonic activity (slow variations) was mainly observed during the second phase, from hand-to-bar contact until actual execution. An example of heart-rate recording is presented in Figure 2.

Phasic Responses During the First Phase

Responses between being called and hand-to-bar contact were observed in 69% of the trials. The chi-square test showed a significant difference between the observed data ($N = 96$) and the expected data, that is, an equal proportion of phasic response and no response: $\chi^2 = 6.72, P < .01$, with df = 1. As far as skin-potential responses

![Figure 2](image-url) — Representative example of heart-rate recording during the preparation period in weight lifting. A strong decrease in heart rate is recorded during the first phase and is thought to be related to focusing attention on a technical aspect of the forthcoming action. Then heart rate increases slowly during the second phase (physiological activation), and a phasic response finally occurs, accompanying execution.
Table 1  Comparison of Phasic Responses During the Preparation Phase From Call to Hands-to-Bar Contact and Those Accompanying Actual Execution*

<table>
<thead>
<tr>
<th>Indicators of autonomic-nervous-system activity</th>
<th>Response quantification (unit)</th>
<th>Preparation, mean (SD)</th>
<th>Execution, mean (SD)</th>
<th>Z (Wilcoxon test), $\chi^2$ (contingency test), $r$ (correlation coefficient)</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin-resistance ohmic-perturbation duration</td>
<td>duration (s)</td>
<td>2.66 (1.44)</td>
<td>4.31 (1.61)</td>
<td>$Z = -2.12$</td>
<td>.05</td>
</tr>
<tr>
<td>Potential (SYDER code)</td>
<td>/</td>
<td>B (43)</td>
<td>B (32)</td>
<td>$\chi^2 = .54$</td>
<td>NS</td>
</tr>
<tr>
<td>Skin temperature</td>
<td>amplitude (°C)</td>
<td>-0.16 (0.11)</td>
<td>-0.25 (0.12)</td>
<td>$Z = -1.69$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>duration (s)</td>
<td>5.11 (2.86)</td>
<td>7.18 (4.5)</td>
<td>$Z = -1.78$</td>
<td>NS</td>
</tr>
<tr>
<td>Skin blood flow</td>
<td>amplitude (mW · cm⁻¹ · °C⁻¹)</td>
<td>-0.26 (0.17)</td>
<td>-0.41 (0.26)</td>
<td>$Z = -0.58$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>duration (s)</td>
<td>3.89 (2.82)</td>
<td>4.05 (2.89)</td>
<td>$Z = -0.18$</td>
<td>NS</td>
</tr>
<tr>
<td>Heart rate</td>
<td>amplitude (beats/min)</td>
<td>-18.94 (8.08)</td>
<td>30.32 (6.45)</td>
<td>$r = -0.31$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>duration (s)</td>
<td>2.9 (2.04)</td>
<td>11.58 (2.57)</td>
<td>$Z = -3.06$</td>
<td>.01</td>
</tr>
<tr>
<td>Respiratory frequency</td>
<td>amplitude (beats/min)</td>
<td>-8.59 (5.96)</td>
<td>5.83 (9.01)</td>
<td>$r = -0.19$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>duration (s)</td>
<td>4.61 (2.67)</td>
<td>4.6 (5.55)</td>
<td>$Z = -0.13$</td>
<td>NS</td>
</tr>
</tbody>
</table>

*Responses during execution are shown to be higher and longer than those during preparation, but differences reached the significant threshold in skin resistance and heart rate only. NS indicates nonsignificant.
were considered, a higher proportion of B response (a sudden variation of basal value followed by slow recovery) was observed, as shown in Table 1. The chi-square test showed a significant difference between the observed data and the expected data, that is, an equal proportion of the A, B, and C response and no response: $\chi^2 = 4.52, P < .05$. Mean heart rate and respiratory frequency decreased strongly: –19 beats/min in heart rate and –8.6 beats/min in respiratory frequency (see Figure 3).

**Comparison of Phasic Responses Between Preparation and Execution**

Phasic responses recorded during the preparation phase (ie, between being called and hand-to-bar contact) were compared with those recorded during actual execution. No significant differences were evidenced in skin-potential, temperature, blood-flow, and respiratory-frequency (duration only) responses. Skin resistance and heart-rate-response duration, however, were shorter during the preparation phase than during the execution period ($P < .05$ for skin resistance, and $P < .01$ for heart-rate-response duration). During the preparation phase, heart rate and respiratory-frequency-response amplitude decreased, whereas they were shown to increase during the execution phase. With reference to each variable, responses were not significantly correlated ($r = –.31, P > .22$, and $r = –.19, P > .34$, respectively). Data are summarized in Table 1.

**Tonic Variations During the Second Phase**

Tonic variations were recorded during the second phase (ie, between hand-to-bar contact and execution) in 77% of the trials. Basal levels thus remain stable in the remaining trials. Comparison of the observed and the theoretical data using

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**Figure 3** — Mean change in phasic responses (ie, heart rate and respiratory frequency) during the preparation period in weight lifting. Strong variations in heart rate and respiratory frequency are elicited within a short period of time while the weight lifters stand motionless in front of the bar.
the chi-square test (N = 96 with 1 df) showed that the difference was statistically significant: $\chi^2 = 14.58$, $P < .001$. The proportion of trials in which basal levels changed was higher than the proportion of trials in which basal levels remained constant. Increased activation was observed in 70% of the trials, and relaxation, in 30%. Using the chi-square test, the comparison of the observed data and the theoretical data (N = 96 with $df = 1$) showed that the difference was significant: $\chi^2 = 4.41$, $P < .05$. The proportion of trials in which increased activation was observed was higher than the proportion of trials in which relaxation was observed. Mean ratios (values recorded when weight lifters began the snatch divided by the values recorded when they put their hands on the bar) were 1.25 for heart rate, 1.22 for respiratory frequency (ie, an increase of about 25% and 22%, respectively), and 0.79 for skin resistance (ie, a decrease of 21%). Ratios were lower than 1 in skin blood flow and skin temperature, although with weaker variations than in heart rate and skin resistance, mean skin blood-flow ratio being $0.87 \pm 0.12$ and mean skin-temperature ratio being $0.96 \pm 0.06$.

**Discussion**

The aim of the experiment was to highlight ANS activity during the preparation period of the weight-lifting snatch in experienced lifters and compare these responses with those elicited by actual execution of the lift. As expected, phasic ANS activity was mainly observed during the first behavioral period and was shown to match those recorded during execution. Another main finding of the experiment was that tonic variations were mainly observed in the second period, thus showing an increase in activation level. Based on these data, it might be possible to analyze the links between physiological activity and behavior.

According to Lacey and Lacey,21 decreased heart rate (ie, phasic activity) is interpreted as an increase in focused attention. It was also described by Stern23 during a period of highly focused attention before action: while participants were waiting for a signal in a reaction-time task (“get set,” time lapse 5 seconds, “go”). Later work by Brunia and Damen22 confirmed that, before 4 different movement responses, cardiac deceleration occurred. Therefore, a decrease in heart rate, as well as an electrodermal response recorded during the first preparation phase, might be related to focused attention. A mean decrease in heart rate of about 19 beats/min associated with a skin-resistance response of about 3 seconds was observed in weight lifters. Thus, the importance of attentional processes during the preparatory period in self-paced motor performances could be emphasized. During this period, weight lifters must maintain focused attention to perform at peak levels, because even minor disruptions in attentional processes can lead to dramatic variations in performance.24,25 If increased attention is required, however, a decrease in heart rate did not provide information about cues on which attention is focused. It appears that the weight lifters focused their attention on particular cues of the forthcoming movements, which they had memorized as determinant to make the trial successful.

Phasic activity from the first preparation phase was shown to resemble that in the accompanying execution. Thus, mental processes from the preparation period evidenced by ANS responses seem to be focused on the forthcoming execution phase. Responses during the preparation period, however, were generally shown
to be shorter and of lower amplitude than those recorded during the execution phase. Two main explanations might be appropriate: The entire lifting movement is not mentally represented, and mental representation is not immediately followed by execution. Only the less skilled sequence is thought to be controlled through attentional resources. Similar responses were recorded during the preparation phase in air-rifle shooting, because execution requires less energy expenditure because autonomic responses during the preparation phase are correlated with those accompanying execution. Two main explanations might be appropriate: The entire lifting movement is not mentally represented, and mental representation is not immediately followed by execution. Only the less skilled sequence is thought to be controlled through attentional resources. Similar responses were recorded during the preparation phase in air-rifle shooting, because execution requires less energy expenditure because autonomic responses during the preparation phase are correlated with those accompanying execution. A close relationship between movement representation (i.e., recalling motor program) and its update during the execution phase was thus established. Boutcher and Zinsser recorded heart-rate deceleration in golf players just before putting (deceleration from 4 to 11 beats/min, and from 3 to 7 seconds). Because energy expenditure and temporal pressure are low in shooting and golf events, participants have time to update memorized motor programs and probably to represent the entire motor sequence mentally.

Putting one’s hands on the bar means that one is ready to act. Skin-resistance, skin-blood-flow, and skin-temperature tonic values decreased as heart-rate, respiratory-frequency, and skin-potential tonic values increased between the contact with the bar and the beginning of lifting: Such variations were all related to increased general activation. An increase in heart rate of 25% and in respiratory frequency of 22% showed that the cardiorespiratory system was involved in mobilizing energy needed to perform the movement. In the same way, a decrease in skin blood flow of 13% (ratio = 0.87) and skin temperature of 4% (ratio = 0.96) showed that blood was redistributed toward the muscles required to lift the bar, that is, vasoconstriction in the skin and vasodilatation in the muscles. In the first period of the preparation, mean skin temperature decreased about 0.16°C within a very short period of time (about 5 seconds), thus demonstrating physiological adaptation required for the movement preparation. Activation is controlled by the sympathetic branch of the ANS, which is known to innervate sweat glands. The release of sweat in response to sympathetic endings activity might explain the decrease in skin resistance associated with the increase in skin potential during the preparation period.

The sympathetic system is known to mobilize a weight lifter’s resources in the event of energy-expenditure demands. Wallin and Fagius, based on recordings of sympathetic-unit activities with microelectrodes, concluded that the ANS is rapidly and selectively activated. In our experiment, lifting a high load required the sympathetic system to mobilize additional resources. The same process was previously observed in the shot put. ANS activity showed a strong increase in activation, for example, tonic increase in heart rate, as well as tonic decrease in skin resistance. Thus, the second requirement to perform well is the mobilization of energetic resources, which was demonstrated by the slow variations in autonomic indicators just before action.

To conclude, mental activity, such as focusing attention on a technical aspect of movement, was evidenced in the weight-lifting preparation period—especially in the first phase. This period could thus be called the vigilance period, in reference to the definition proposed by Caldwell et al. On the other hand, the second preparation phase showed an increase in general arousal, particularly at the level of the muscles (activation). Weight lifters were thus shown to separate the directional and intensive requirements of the task into 2 distinct stages, probably to share mental resources among these 2 demanding phases. Because the rules of weight
lifting allow the athletes to take the time they need to prepare themselves without firm time constraints (after they are called, 1 minute before lifting is available), athletes could process information related to vigilance and activation separately. Separating these 2 mental processes that are required to perform well is allowed by low time constraints and is related to the well-known theory of limited information-processing ability.30

Until now, mental operations performed by weight lifters were not apparent to coaches despite their behavioral observation (ie, the 2 concentration phases described in the introductory section). The preparation phase is a determining factor of the subsequent performance, however, so coaches should be aware of the mental content of these 2 distinct preparation phases and encourage their athletes to dissociate their focus from increasing physiological activation. Consequently, further research is necessary to ascertain whether the current results can be generalized to sporting activities requiring quite different spatial and temporal constraints.

References