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INTENSE ACOUSTIC STIMULATION DOES NOT AFFECT SUBSEQUENT VERTICAL JUMP PERFORMANCE IN HUMANS

Benjamin A. Crockett
Northern Michigan University

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INTENSE ACOUSTIC STIMULATION DOES NOT AFFECT SUBSEQUENT VERTICAL JUMP PERFORMANCE IN HUMANS

By

Benjamin A. Crockett

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This thesis by Benjamin A. Crockett is recommended for approval by the student's thesis committee and Department Head in the Department of Health, Physical Education and Recreation and by the Dean of Graduate Studies and Research.

Committee Chair: Dr. Randall Jensen Date

First Reader: Dr. Phillip Watts Date

Second Reader: Dr. Cynthia Prosen Date

Department Head: Dr. Harvey Wallace Date

Dean of Graduate Studies: Dr. Cynthia Prosen Date

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NAME: Crockett, Benjamin Adams

DATE OF BIRTH: December 2, 1980

ABSTRACT

INTENSE ACOUSTIC STIMULATION DOES NOT AFFECT SUBSEQUENT VERTICAL JUMP PERFORMANCE IN HUMANS

By

Benjamin A. Crockett

Organisms, including humans, react physiologically to environmental threats to avoid injury or death. A burst of broadband noise has been used as a stimulus with humans to mimic the response displayed in a threatening situation. Generating a defensive response via acoustic stimulation could lead to increases in muscular performance, based on known physiological reactions. The vertical jump test is the principal field test to determine power in the legs. The aim of this study was to characterize the effect of a burst of noise on subsequent jumping performance. Sixty untrained men and 60 untrained women were allocated to one of three jumping conditions (3, 8, or 15-seconds post-acoustic stimulation). Subjects were positioned on a force plate with a speaker located 0.3 m from their face. A 100 dB(A) broadband acoustic stimulus was delivered to half of subjects in each time condition, while the other half of the subjects received no noise stimulus. The subjects then performed a counter movement jump according to group assignment. Utilizing a crossover design, subjects performed the same jump with the opposite stimulus condition. Data collected included; flight time (FT), peak force (PF), and time to peak force (TTPF). A 2 x 3 x 2 ANOVA (presence or absence of stimulus x post-AS time of jump x gender) showed no significant effect from acoustic stimulation. Findings suggest that an acoustic stimulus 3, 8 or 15 seconds before a human performs a vertical jump has no significant effect on performance measured by FT, PF or TTPF. **Key Words: Startle, Jumping, Muscular Power, White Noise**

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This thesis follows the format prescribed by the *Journal of Applied Physiology* as recommended by the Department of Health, Physical Education, and Recreation.

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I. MANUSCRIPT SUBMISSION

Journal of Applied Physiology

Introduction

All organisms, including humans, react physiologically to environmental threats to avoid injury or death. The origins of a defensive response concept are found in the writings of Pavlov and Cannon in the late 1920's (7, 22). The phrase 'defense reflex' was used by Pavlov to describe protective responses to various stimuli, such as the withdrawal of a hand from an electric shock. Cannon's work in this area led to his formulation of the term 'fight-or-flight response'. This was described by Cannon as a response to an emergency situation which facilitates muscular-dependent behaviors such as attack or evasion.

In 1956, Selye, who was influenced by the work of Cannon many years earlier, conceptualized the physiology of stress with a set of responses he termed the 'general adaptation syndrome'. The first of these he called the 'general alarm reaction', and considered it to be an expression of alarm by the organism when suddenly confronted with a critical situation (25).

Typical human defensive responses reported in modern literature include; freezing, startle, fainting, fleeing or fighting (28). Many factors modulate which response will occur in a particular setting. Recent research has attempted to elucidate and differentiate the nature of the psychological and environmental situations that will produce each of the specific types of defensive action (23). At its most severe, physiological defense may take the form of mass sympathetic nervous system discharge and hormonal response which facilitate swift and sustained reactions associated with a preparation for aggressive muscular action. These reactions may include increased arterial pressure, increased blood flow to skeletal muscle, increased rate of cellular metabolism throughout the body, and increased glycolysis in the liver and muscle (16).

Research on the defensive responses of humans often utilizes an intense burst of ‘white noise’ as a stimulus to produce an autonomic response similar to that seen in a threatening situation. True white noise can contain a wide range of frequencies; however, the term “white noise”, as used in human startle studies, is generally defined as a broadband sound containing frequencies between 20 Hz and 20,000 Hz (4). White noise has been shown to be a more effective startle stimulus then a pure tone (4, 5). Intense acoustic stimulation in humans has been demonstrated to cause involuntary eye-blink, increases in skin conductance, changes in heart rate and blood pressure, skeletal muscle contractions and an increase in reaction time (28).

Generating a stress response in humans via acoustic stimulation may lead to a discrete increase in muscular performance, based on known physiological reactions. In a classic paper, Ikai and Steinhaus showed that maximal voluntary strength of the elbow flexors could be increased by auditory cues, such as firing a gun 2, 4, 6, 8 or 10 seconds before maximal efforts (18). Since then, few published studies have attempted to quantify specific gains in muscular strength or power using acoustic stimulation. No known studies have investigated lower body muscle performance. The vertical jump test is the principal field test to determine muscular power in the legs. The purpose of this study was to determine if an intense acoustic stimulus (AS) would improve ensuing performance in a vertical jump in apparently healthy humans.

Materials and Methods

Subjects. Sixty untrained men and sixty untrained women volunteered to participate in this investigation. The subjects gave informed consent and the study was approved by the Human Subjects Research Review Committee of Northern Michigan University (#HS08-187). None of the participants reported auditory deficits or cardiovascular problems. Subjects were allocated, at random, to one of three jumping conditions (3, 8, or 15 seconds post-AS) with the restriction that each group contained equal numbers of men and women. Utilizing a crossover design, each of these groups were then divided, with 50% of subjects scheduled to receive an AS prior to their first experimental jump and 50% scheduled to receive an AS prior to their second experimental jump to control for ordering effects.

Procedures. Prior to performing the experimental measurements, subjects were familiarized with the test procedures during a brief orientation session. They were informed that they may hear “some noise” at any point during the testing and they were to ignore it. Subjects then sat quietly for 5:00 minutes. Following this, subjects began testing by standing motionless on a 50.8 x 46.4 cm force plate (OR6-5, AMTI, Watertown, MA, USA). The force plate was zeroed before each subject stepped onto the surface. Throughout testing, kinetic data from the plate were collected at 1000 Hz and saved with computer software (NetForce 2.0, Advanced Mechanical Technologies, Inc., Watertown, MA USA) for later analysis.

A speaker (AN-130, Anchor Audio, Inc., Torrance, CA, USA), connected to the audio system used to generate a white noise AS (100 dB(A), 0.50 sec duration, with near instantaneous rise time), was positioned 0.30 m directly anterior to the subject’s face. The intensity of the AS was calibrated with a sound pressure meter (#407730, Extech, Inc., Waltham, MA, USA). While aversive, this sound level is considered safe for human subjects, as it is far below the threshold the United States Occupational Safety and Health Administration has established for occupational safety (4). It has been used frequently in psychophysiological research (13).

Half of subjects in each time condition then received an AS, while the other half of subjects received no noise stimulus. Following the stimulus (or silent period) the subjects then performed a maximal vertical counter movement jump (CMJ) with a 3, 8, or 15 second delay according to their group assignment. A 20-second digital countdown clock was positioned in the subject’s view to inform them of the time they should jump.

During the counter movement jump, the participant’s hands were kept on the hips to minimize the contribution of the upper limbs. The jump was started from a standing position, followed by squatting down and then extending the knees in one continuous movement. The depth of squat was self selected.

Following the first jump test, the subjects sat quietly for 5:00 minutes to minimize fatigue. In accordance with the crossover design of this study, each subject then performed the same jump with or without the stimulus, depending on their initial trial assignment.

The data collected from all CMJ trials included flight time in ms (FT), peak force in N (PF), and time to peak force in ms (TTPF). FT was determined using the time-force record, with take-off time subtracted from landing time. Peak force was defined as the maximal value attained during the concentric portion of the CMJ. Time to peak force was defined as the difference in the force-time record from the beginning of concentric force production to the point at which the subjects reached their PF. Concentric force production was assumed to begin when the vertical ground reaction force exceeded body mass.

Statistical Analysis. A 2 (presence or absence of AS) x 3 (post-AS time of jump) x 2 (gender) analysis of variance (ANOVA) was used to analyze differences between means for the dependent variables. The level of significance was established at $p \leq 0.05$. The statistical analysis was performed using SPSS 15.0 (SPSS Inc., Chicago, IL, USA).

Results

The characteristics of the subjects who volunteered for this investigation are presented in Table 1. Of the 120 total subjects, 60 were male and 60 were female. The means and standard deviations of the male subjects' age, weight and height were 22.67 ± 4.25 yr, 87.92 ± 19.88 kg and 1.82 ± 0.07 m, respectively. For females, the means and standard deviations were 21.28 ± 3.50 yrs, 67.69 ± 10.82 kg and 1.69 ± 0.07 m.

Vertical Jump Flight Time

Descriptive statistics for the vertical jump flight times are presented in Figure 1. A 2 (presence or absence of AS) x 3 (post-AS time of jump) x 2 (Gender) ANOVA was performed on the flight time of participants' maximal CMJs. There was no significant main effect for the presence of AS, $F(1,114) = 2.88$, $p > .05$ or for the post-AS time of jump, $F(2,114) = 0.02$, $p > .05$. There was a significant main effect for gender, $F(1,114) = 55.64$, $p < .05$. In general, male participants had a longer flight time (454.39 ± 61.59 ms) than did female participants (379.77 ± 53.08 ms). There were no significant interactions for: presence of AS x gender, presence of AS x post-AS time of jump, gender x post-AS time of jump, or presence of AS x gender x post-AS time of jump.

Peak Force

Descriptive statistics for the vertical jump concentric PF are presented in Figure 2. A 2 x 3 x 2 ANOVA was calculated on the concentric peak force of participants' maximal CMJs. There was no significant main effect for the presence of AS, $F(1,114) = 2.57$, $p > .05$ or for the post-AS time of jump, $F(2,114) = 1.41$, $p > .05$. There was a significant main effect for gender, $F(1,114) = 53.60$, $p < .05$. In general, male participants had a higher concentric peak force (202.81 ± 37.05 N) than did female participants (153.23 ± 37.76 N). There were no significant interactions for: presence of AS x gender, presence of AS x post-AS time of jump, gender x post-AS time of jump, or presence of AS x gender x post-AS time of jump.

Time to Peak Force

Descriptive statistics for the vertical jump TTPF are presented in Figure 1. A 2 x 3 x 2 ANOVA was calculated on the TTPF of participants' maximal CMJs. There was not a significant main effect for the presence of AS, $F(1,114) = 1.71$, $p > .05$ or for the post-AS time of jump, $F(2,114) = 0.27$, $p > .05$. There was a significant main effect for gender, $F(1,114) = 10.25$, $p < .05$. In general, male participants had a longer time to peak force (309.53 ± 145.89 ms) than did female participants (237.02 ± 134.04 ms). There were no significant interactions for: presence of AS x gender, presence of AS x post-AS time of jump, gender x post-AS time of jump, or presence of AS x gender x post-AS time of jump.

Discussion

Our findings suggest that the presentation of an intense acoustic stimulus 3, 8 or 15 seconds before a human performs a vertical counter movement jump has no statistically significant effect on their performance, as measured by FT, PF or TTPF. This study demonstrated that the male subjects, on average, were able to produce significantly longer flight times and higher peak forces than female subjects, which is typical. Male subjects also showed longer TTPF, compared to females.

The importance of this study is that it failed to demonstrate that the autonomic physiological reactions that are associated with intense noise translate into improved performance on a muscle power task. This exploratory research seems to conflict with the notion that a threatening situation enhances muscular performance for aggressing or fleeing. There are several possible reasons that this experiment did not give expected results.

Subjects were asked to perform a maximal vertical jump on each of their trials. A ceiling may exist which limits performance improvements, due to individual restrictions on the speed of muscular contraction, complete utilization of muscle fibers, a protective mechanism in the CNS, or other factors (12). However, Ebben et al. showed an increase in maximal vertical jump performance using only jaw clenching as an ergogenic technique (10). This seems to indicate that maximal jumps of this type can be enhanced in untrained subjects with non-pharmacological methods.

It may also be possible that subjects did not perceive the stimulus as threatening. The physiological responses to acoustic stimulation are modulated by many factors including, gender, age, the nature of the stimulus, and environmental factors such as the ambient light and sound levels of the testing area (13, 20, 21, 23, 24). However, the researchers subjectively noticed a visible flinching of the body in most subjects at the time the stimulus was delivered.

The vertical jump test may not have tested musculature which is activated by an AS. The original research of Ikai and Steinhaus tested the muscles of the upper limbs when they showed improvements in strength following a gunshot (18). Kofler et al. found that reflexes were more prevalent in facial and neck muscle, compared to extremity muscle, and more frequent in arms than in the legs (20). This may account for the differences in our findings. Another divergence which may account for these results is that the vertical jump is a test of muscular power. Ikai and Steinhaus used an isometric maximal voluntary contraction in their research. The coordinated movements of a whole body power task may not be affected as drastically as a single sustained muscle contraction.

Several limitations existed in this experimental procedure. Possibly the most consequential of the limitations was that performance measures were the only data sampled. Physiological measures such as heart rate, blood pressure, skin conductance or electromyography might have established a more complete understanding of why muscular power was not improved in the legs in this experiment. Obvious limitations also exist in the nature of any defense reaction research, as human subjects cannot undergo excessive stress and still conform to human subject protection guidelines.

Future research should attempt to clarify how muscular performance and defensive reactions are related. Although the physiological reactions to intense sound and other stimuli are reasonably well understood, performance improvements have not been studied sufficiently. Researchers should consider varying the nature of the stimuli, the timeframe of the stimuli delivery, or the type of muscle task. This research used 3, 8 and 15 second delays to reflect the original research of Ikai and Steinhaus that used similar delays of 2, 4, 6, 8 and 10 seconds. It is possible that the neurological responses occur before 3 seconds or latent responses occur after 15 seconds.

Table 1. Characteristics of the male and female subjects(Mean ± SD)

	Males	Females
N	60	60
Age, yr	22.67 ± 4.25	21.28 ± 3.50
Body weight, kg	87.92 ± 19.88	67.69 ± 10.82
Height, m	1.82 ± 0.07	1.69 ± 0.07

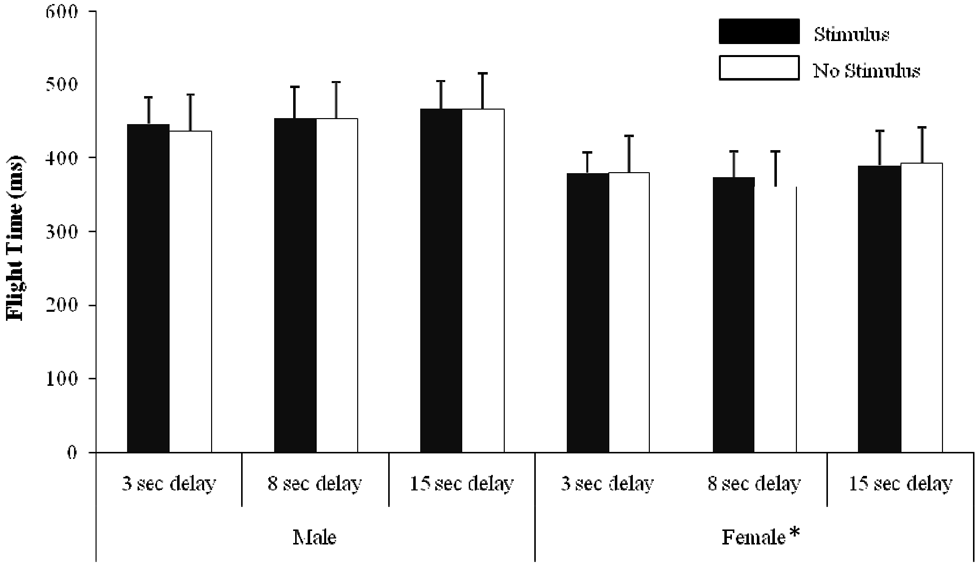

Figure 1. Mean (± SD) flight times of countermovement vertical jumps.
** No significant effects existed (p > 0.05) except between genders.*

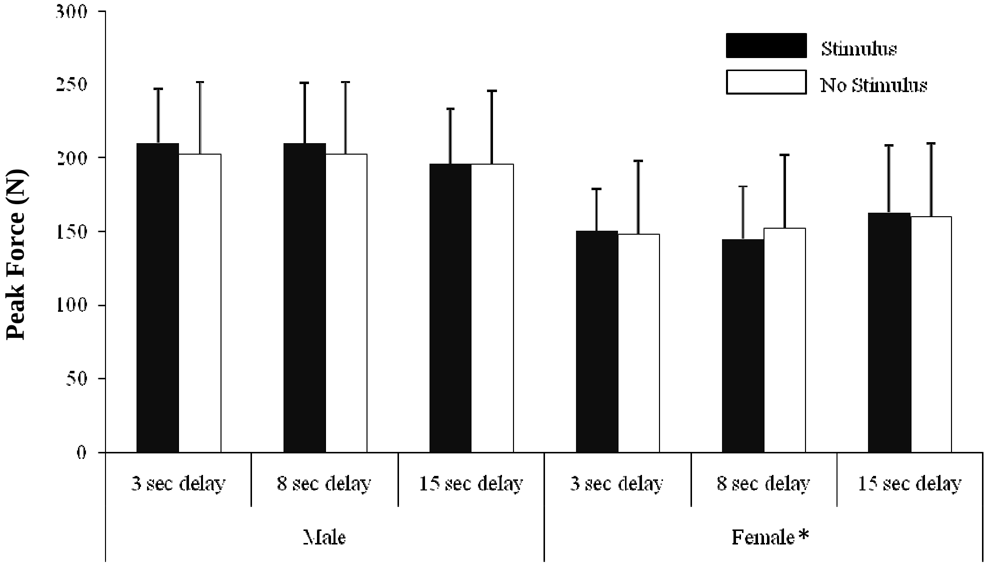

Figure 2. Mean (± SD) peak force attained during vertical jumps.
** No significant effects existed (p > 0.05) except between genders.*

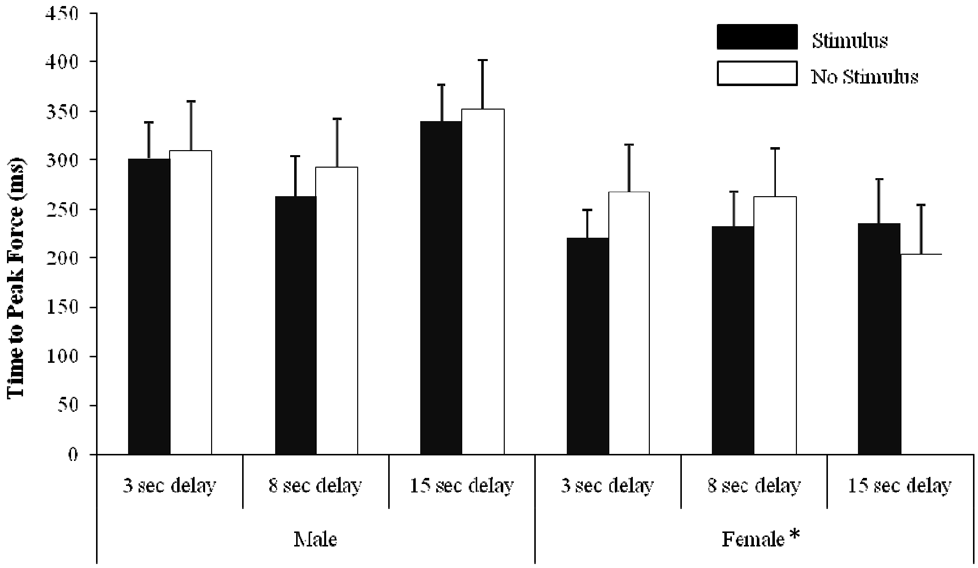

*Figure 3. Mean (± SD) time to peak force of countermovement vertical jumps. * No significant effects existed (p > 0.05) except between genders.*

II. REVIEW OF LITERATURE

Introduction

The acute stress response describes the manner in which humans react to physical or psychological threats with a mass discharge of the sympathetic nervous system. This is thought to prime the organism for a defensive action. Research in defensive response often utilizes an intense burst of white noise as a stimulus to produce an autonomic response similar to that observed in a threatening situation. It seems reasonable to assume that generating a defensive response in humans via acoustic stimulation may lead to a discrete increase in muscular performance, based on the known physiological reactions.

This literature review will document and critically evaluate published investigations which support, or provide contextual information for, the determination of whether an intense acoustic stimulus will improve ensuing performance in explosive muscular power tasks.

The review is divided into several sections. The first section describes several classic models descriptive of the defensive responses observed in humans. This provides the historical framework necessary for the appreciation of contemporary theory and experimentation. The second section focuses on common methodology utilized in experimental protocols involving intense acoustic stimulation. The third section elucidates the physiological responses acoustic stimulation elicits in controlled studies. This forms a foundation for building the hypothesis of the current original investigation. The final section describes several studies that validate the use of the vertical jump as a measure of muscular performance and provide reliable methods for measurement.

Classic Models of Defensive Response

The origins of the defensive response concept are found in the writings of Pavlov and Cannon (7, 22) in the late 1920's. The phrase 'defense reflex' was used by Pavlov to describe protective responses to various stimuli, such as the withdrawal of a hand from an electric shock. Cannon's work in this area led to his formulation of the term 'fight-or-flight response'. This was described by Cannon as a cardiovascular response to an emergency situation that facilitates muscular-dependent behaviors such as attack or evasion.

In 1956, Selye, influenced by the work of Cannon many years earlier, conceptualized the physiology of stress with a set of responses he termed the 'general adaptation syndrome'. He called the first response the "general alarm reaction", and considered this first stage to be an expression of alarm from the organism when suddenly confronted with a critical situation (25).

Graham and Clifton, in a 1966 paper, developed a classification system, based on cardiac responses to acute stress, which has broadly affected research on defensive responses (15). The system, later expanded and developed by Graham, proposed four basic reflexes which are determined based on the eliciting stimuli's intensity and transient/sustained characteristics. They were described as: the transient detection reflex, the orienting reflex, the startle reflex, and the defense reflex (14). These reflexes were thought to exhibit divergent physiological components including differences in cardiac response and habituation. This classification system has been continuously challenged and revised (2, 8, 23, 27, 28, 29).

A recent challenge to the entire concept of defensive response came from Taylor et al. in 2000 (26). This paper postulates that the fight-or-flight response originally observed by Cannon may not exclusively, or even predominantly, explain female response to acute stress. Instead, Taylor and coworkers suggest that while the basic neuroendocrine stress response does not seem to vary between males and females, a stress response geared toward aggressing or fleeing may not suit the evolutionary needs of females who are often caring for offspring. 'Tending and befriending' (blending into an environment and quieting children) mediated by a strong oxytocin release may be more adaptive compared to aggressively attacking, or fleeing from, a predator (26).

Research Methods Utilizing Intense Acoustic Stimulation

Many types of aversive stimuli have been used to elicit a defensive reaction in humans and animals. These include intense visual, electrical, magnetic, and mechanical types of stimulation. This literature review focuses on the most commonly employed method an intense burst of sound.

Nature of Stimuli

The nature of the physiological defensive response to sound is modulated by the properties of the stimulus, including intensity, duration, band-width, and rise time (3, 23, 28). These differing physiological responses will be described in detail in a subsequent section; the following description details common acoustic stimulus parameters.

Research in defensive responses using intense acoustic stimulation most commonly utilizes broadband noise containing frequencies between 20 Hz and 20 kHz (4). Broadband noise is a more effective startle stimulus than a pure tone (4, 5).

In terms of intensity, eye-blink startle responses have been demonstrated at levels as low as 50 dB(A) (5). However, the majority of acoustic startle studies have employed intensities at or above 100 dB(A). This is due, in part, to the observation that lower levels have been shown to decrease the probability of a response (4).

Stimulus duration also appears to affect the defensive response exhibited. For eye-blink response, durations of approximately 50 ms are often utilized and are thought to be sufficient for startle elicitation (4). Studies investigating the cardiac defense response to acoustic stimulation have used stimuli up to 1000 ms in length (23).

The rise time, a measure of how quickly the stimulus reaches its steady-state amplitude, has also been shown to influence the defensive response in humans, with faster times increasing effectiveness. Blumenthal et al. point out that "even the fastest rise time must have some finite value", thus reporting rise-time as instantaneous is misleading (4). One consequence of fast rise times is the occurrence of 'frequency splatter', meaning that the sound is more intense and of wider bandwidth than intended (3).

Equipment

The equipment necessary to create an intense acoustic stimulation for human subjects includes the following, as described by Blumenthal et al. in their committee report, giving guidelines for human startle studies.

The sound may be generated with computer software and sound cards or with commercial noise generators. Software may provide a more precise bandwidth composition. A frequency range extending to 20 kHz includes the highest frequencies to which humans are responsive (4). The acoustic stimulus may be delivered via loudspeakers or headphones, with headphones delivering a more uniform and reliable signal (4). A sound level meter may be used to calibrate the sound intensity, with most researchers reporting measurements using the dB(A) SPL scale (4). Further, a Fourier analysis can be used on a sampled stimulus to determine bandwidth composition (4).

Safety Considerations

Due to the intense nature of the sound used to elicit the acoustic defensive reaction, concern may arise regarding the safety of the stimulus to research subjects. Two references relating to the danger of this level of sound are provided. The first states that noise up to 110 dB(A) is ‘safe’ and is fairly representative of the intensity used by most authors who conduct research in this area. The second describes the sounds as far below the threshold OSHA has established for occupational safety, but cautions that the noise is likely 'aversive' to subjects.

> "The large majority of studies rely on acoustic startle, evoked by short (up to 50 ms) noises, usually broadband or white noise with a high intensity (90-110 dB). Despite its relatively high intensity, the white noise used to evoke startle is safe in terms of its potential effects on the auditory system because of its very short duration." (13 p. 1558)

> "The United States Occupational Safety and Health Act standards (OSHA standard number 1910.95) state that, at a stimulus intensity of 105dB SPL, hearing protection is not required unless the sound is continuous for 1 h. However, this refers to constant stimulation, not to impulse stimuli, such as those used to elicit startle. Although a 50-ms-duration stimulus at 105 dB would still be

> well below the level that OSHA regards as unsafe, less intense stimuli are likely to be less aversive for most subject groups." (4 p. 4)

In addition to these direct statements, there is a large body of contemporary research utilizing this type of probe in neurophysiology and psychology, including studies investigating the cardiac defense response that have used stimuli over 100 dB(A) and up to 1000 ms in length (23). Grillon and Baas stated in a 2003 review article that in the last two decades there has been a steady increase in the number of human studies using the acoustic startle reflex (13).

Physiological Responses to Intense Acoustic Stimulation

When a human is subjected to an intense acoustic stimulation, several important physiological reactions can occur. Many factors modulate these responses, including gender, age, the nature of the stimulus, pre-pulse presentation (the presentation of a lower intensity noise directly preceding the stimulus), preexisting pathological conditions, pharmacological interventions, and environmental factors such as the ambient light and sound levels of the testing area (13, 20, 21, 23, 24). The following sections provide a brief overview of the two most common reactions to intense noise reported in the literature.

Muscular Contraction

The reaction of skeletal muscle to an unexpected intense acoustic stimulus is thought to be an oligosynaptic lower brainstem reflex that is mediated by neurons of the caudal pontine reticular nucleus (19, 30). The result is a closure of the eyelid and a twitch of the facial, neck, and extremity musculature. This ‘startle pattern’ includes an anterior thrust of the head and a cascading wave of flexor contractions extending from the trunk though the extremities (14). The eyeblink muscle response, in particular, has been widely used as a measure in experimental psychology. Kofler et al. found that reflexes were more prevalent in facial and neck muscle, compared to extremity muscle, and more frequent in arms than in the legs, with median latencies from 33 ms in the orbicularis oculi upward to 142 ms in the soleus (20).

Cardiovascular Changes

The cardiovascular response to intense acoustic stimulation was described first in cats and dogs by Bond, who found a heart rate pattern characterized by two accelerative and two decelerative components in alternating order, following the stimulus presentation (6). This pattern has been consistently confirmed in humans in many studies (28). The first heart rate acceleration reaches a peak around 3 seconds after the stimulus. This is followed by the first heart rate deceleration. A second, and longer, acceleration peaks at around 35 seconds, followed by the final deceleration. Some individuals do not seem to exhibit a second acceleration, prompting Eves and Gruzelier to classify people as accelerators or non-accelerators (11). According to a review paper by Vila et al., this complex pattern of heart rate changes likely has sympathetic and parasympathetic mediation with cognitive and motivational modulation (28).

Muscular Performance Improvements

In a classic paper, Ikai and Steinhaus showed that maximal voluntary strength of the elbow flexors could be increased by auditory cues, such as firing a gun 2-10 seconds before maximal efforts (18). Since then, few published studies have attempted to quantify specific gains in muscular strength or power using acoustic stimulation. No known studies have investigated lower body muscle performance.

Measurement of Vertical Jump

The vertical jump test is the principal field test to determine muscular power in the legs. There are several types of vertical jump protocols reported in the literature (17). The most common are the squat jump, the drop jump, and the counter movement jump (CMJ). This experimental research will utilize the CMJ.

In the CMJ, subjects start in a standing position then drop into a squatting position. With no pause, they then jump upwards as high as possible from the bottom of the squat. The CMJ can be performed with or without the contribution of arm motion.

The reliability of CMJ tests are reported to be quite high. For instance, Ashley and Weiss showed an intra-class correlation coefficient for a CMJ of 0.87 for repeated testing separated by 48 hours (1).

The direct measurement of power output in a CMJ requires the use of a force plate. Flight time, peak force and time to peak force were used by Ebben et al. to analyze CMJ data from a force plate (9).

III. CONCLUSIONS AND RECOMMENDATIONS

Summary and Conclusions

The findings of this research suggest that the presentation of an intense acoustic stimulus 3, 8 or 15 seconds before a human performs a vertical counter movement jump has no statistically significant effect on performance as measured by FT, PF or TTPF. This study demonstrated that the male subjects, on average, produced significantly longer flight times and higher peak forces than female subjects, as is typical. Male subjects also showed longer TTPF, compared to females.

The importance of this study is that it failed to demonstrate that the autonomic physiological reactions that are associated with intense noise translate into improved performance on a muscle power task. This exploratory research seems to conflict with the notion that a threatening situation enhances muscular performance for aggressing or fleeing.

Recommendations

Several limitations existed in this experimental procedure. Performance measures were the only data sampled. Physiological measures such as heart rate, blood pressure, skin conductance or electromyography could have established a more complete understanding of why muscular power was not improved in the legs in this experiment. Obvious limitations also exist in the nature of any defense reaction research, as human subjects cannot undergo excessive stress and still conform to human subject protection guidelines.

Future research should attempt to clarify how muscular performance and defensive reactions are related. Although the physiological reactions to intense sound and other stimuli are reasonably well understand, performance improvements have not been studied sufficiently. Researchers may consider varying the nature of the stimuli, the timeframe of the stimuli delivery, or the type of muscle task.

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APPENDICES

APPENDIX A

NORTHERN MICHIGAN UNIVERSITY
DEPARTMENT OF HPER

CONSENT TO ACT AS A HUMAN SUBJECT

Subject Name (print):____Date___________

1. I hereby volunteer to participate as a subject in exercise testing. I understand that this testing is part of a study entitled: “Effect of Intense Acoustic Stimulation on Subsequent Counter-Movement Jump Performance” The purpose of this study is to determine if an intense acoustic stimulus will improve ensuing performance in a vertical jump.

   I hereby authorize Randall L. Jensen, Benjamin A. Crockett and/or appropriate assistants as may be selected by them to perform on me the following procedures:

   (a) I will be measured for height, weight and asked for my age.

   (b) I will then be asked to perform one maximal effort vertical jump off of a force platform. I may hear some loud noise at any time during testing. Following this I will rest for five minutes.

   (c) I will then complete a second vertical jump in a similar way. Following this I will again rest for five minutes

   (d) Following the session I will be debriefed

2. The procedures outlined I paragraph 1 have been explained to me.

3. I understand that the procedures described in paragraph 1 involve the following risks and discomforts: There is a possibility of injury during jumping from the force plate; however, this is anticipated to be of no greater risk than common plyometric exercises utilized for fitness. White noise has been shown to be a safe modality for this type of testing. It is full spectrum sound which is not thought to damage tissues of the ear when used infrequently.

4. I have been advised that the following benefits will be derived from my participation in this study: There will be no direct benefit to me other than the experience of participating in research. Information gained from the study will help the researcher determine whether using an acoustic stimulation will increase the vertical jump of humans.

5. I understand that Randall L. Jensen, Benjamin A. Crockett and/or appropriate assistants as may be selected by them will answer any inquiries that I may have at any time concerning these procedures and/or investigations.

6. I understand that all data, concerning myself will be kept confidential and available only upon my written request, I further understand that in the event of publication, no association will be made between the reported data and myself.

7. I understand that there is no monetary compensation for my participation in this study.

8. I understand that in the event of physical injury directly resulting from participation, compensation cannot be provided.

9. I understand that I may terminate participation in this study at any time without prejudice to future care or any possible reimbursement of expenses, compensation, or employment status.

10. I understand that if I have any further questions regarding my rights as a participant in a research project I may contact Dr. Cynthia Prosen of the Human Subjects Research Review Committee of Northern Michigan University (906-227-2300) cprosen@nmu.edu. Any questions I have regarding the nature of this research project will be answered by Dr. Randall Jensen (906-227-1184) rajensen@nmu.edu of Benjamin Crockett (906-227-2540) bcrocket@nmu.edu

Subject’s Signature____

Witness_____________________________________Date________________

APPENDIX B

IDNumber	Gender (1=F, 2=M)	Time Condition (1=3, 2=8, 3=15)	Sound Given (1=1st Trial, 2=2nd Trial)	Flight Time (ms) Sound	Flight Time (ms) No Sound	Peak Force (N) Sound	Peak Force (N) No Sound	Time to Peak Force (ms) Sound	Time to Peak Force (ms) No Sound
3FI1	1	1	1	347	338	107.91	101.56	150	329
3FI2	1	1	1	451	465	185.00	195.78	350	180
3FI3	1	1	1	335	313	179.25	181.02	117	121
3FI4	1	1	1	356	383	187.81	198.44	183	200
3FI5	1	1	1	440	413	154.74	138.35	214	384
3FI6	1	1	1	422	420	144.10	153.70	253	293
3FI7	1	1	1	396	378	120.48	117.82	154	163
3FI8	1	1	1	324	283	180.28	185.74	157	170
3FI9	1	1	1	367	395	137.90	140.56	118	208
3FI10	1	1	1	419	372	171.71	169.35	169	140
3FII1	1	1	2	387	372	133.62	161.68	123	91
3FII2	1	1	2	389	444	110.74	150.90	569	261
3FII3	1	1	2	386	378	178.95	183.53	154	414
3FII4	1	1	2	451	443	150.16	139.82	385	583
3FII5	1	1	2	362	363	132.89	132.89	255	256
3FII6	1	1	2	487	480	147.20	142.33	417	292
3FII7	1	1	2	371	381	169.06	144.99	184	234
3FII8	1	1	2	202	280	191.20	166.55	162	237
3FII9	1	1	2	373	349	102.17	89.92	135	339
3FII10	1	1	2	345	351	126.83	65.28	174	437
8FI1	1	2	1	411	408	112.06	112.79	529	602
8FI2	1	2	1	415	387	121.83	130.62	338	171
8FI3	1	2	1	391	312	123.58	181.60	164	128
8FI4	1	2	1	429	395	128.60	126.24	169	209
8FI5	1	2	1	375	359	186.63	195.93	136	141
8FI6	1	2	1	391	379	139.97	143.81	349	350
8FI7	1	2	1	395	332	166.40	169.80	181	441
8FI8	1	2	1	346	332	155.47	135.69	136	380
8FI9	1	2	1	311	276	120.63	147.95	207	129
8FI10	1	2	1	423	413	138.05	143.37	178	158

IDNumber	**Gender** (1=F, 2=M)	**Time Condition** (1=3, 2=8, 3=15)	**Sound Given** (1=1st Trial, 2=2nd Trial)	**Flight Time (ms)** Sound	**Flight Time (ms)** No Sound	**Peak Force (N)** Sound	**Peak Force (N)** No Sound	**Time to Peak Force (ms)** Sound	**Time to Peak Force (ms)** No Sound
8FII1	1	2	2	296	300	139.40	143.55	172	117
8FII2	1	2	2	378	388	62.77	119.00	606	690
8FII3	1	2	2	359	375	169.80	168.76	189	204
8FII4	1	2	2	400	412	180.43	229.15	375	113
8FII5	1	2	2	400	392	174.96	171.27	162	147
8FII6	1	2	2	371	364	224.72	198.44	112	129
8FII7	1	2	2	376	381	134.36	129.93	164	193
8FII8	1	2	2	355	326	113.84	100.25	189	593
8FII9	1	2	2	321	317	181.16	176.00	166	182
8FII10	1	2	2	347	362	128.60	116.64	127	164
15FI1	1	3	1	379	360	138.43	139.65	177	152
15FI2	1	3	1	467	470	118.16	115.48	127	123
15FI3	1	3	1	426	411	161.87	177.25	173	109
15FI4	1	3	1	347	379	134.80	150.75	460	173
15FI5	1	3	1	401	404	257.50	219.55	109	144
15FI6	1	3	1	457	412	156.06	118.41	116	157
15FI7	1	3	1	354	331	187.66	160.50	144	320
15FI8	1	3	1	426	423	120.19	122.55	565	211
15FI9	1	3	1	496	518	137.02	133.33	364	227
15FI10	1	3	1	462	490	154.44	166.25	226	168
15FII1	1	3	2	249	319	133.03	134.21	121	114
15FII2	1	3	2	355	362	163.00	155.47	393	411
15FII3	1	3	2	450	456	249.23	243.77	147	158
15FII4	1	3	2	393	378	96.71	95.68	372	335
15FII5	1	3	2	325	321	251.89	252.63	163	160
15FII6	1	3	2	328	313	201.54	245.25	124	98
15FII7	1	3	2	338	331	124.91	121.96	310	407
15FII8	1	3	2	373	354	146.47	149.72	367	264
15FII9	1	3	2	428	435	172.45	143.51	132	180
15FII10	1	3	2	362	378	164.33	155.18	117	179

IDNumber	**Gender** (1=F, 2=M)	**Time Condition** (1=3, 2=8, 3=15)	**Sound Given** (1=1st Trial, 2=2nd Trial)	**Flight Time (ms)** Sound	**Flight Time (ms)** No Sound	**Peak Force** (N) Sound	**Peak Force** (N) No Sound	**Time to Peak Force (ms)** Sound	**Time to Peak Force (ms)** No Sound
3MI1	2	1	1	349	365	187.66	153.85	226	359
3MI2	2	1	1	433	427	204.05	197.40	220	318
3MI3	2	1	1	453	493	185.45	187.07	367	458
3MI4	2	1	1	536	488	156.21	152.67	496	235
3MI5	2	1	1	331	341	230.19	231.37	81	93
3MI6	2	1	1	600	606	227.67	205.68	171	231
3MI7	2	1	1	500	517	179.25	191.80	389	321
3MI8	2	1	1	380	364	217.64	225.02	604	368
3MI9	2	1	1	409	306	250.41	204.20	113	148
3MI10	2	1	1	420	417	176.15	172.45	654	435
3MII1	2	1	2	427	438	239.19	216.45	179	312
3MII2	2	1	2	428	452	194.30	162.86	175	449
3MII3	2	1	2	460	448	186.04	179.84	211	243
3MII4	2	1	2	418	387	282.90	301.94	249	135
3MII5	2	1	2	519	513	204.50	209.51	518	408
3MII6	2	1	2	468	465	184.56	178.06	369	397
3MII7	2	1	2	546	510	162.85	179.10	404	309
3MII8	2	1	2	463	438	216.90	203.46	297	584
3MII9	2	1	2	390	403	241.40	207.30	200	266
3MII10	2	1	2	399	352	286.29	276.25	107	123
8MI1	2	2	1	478	498	177.98	178.47	176	159
8MI2	2	2	1	471	436	198.44	194.90	128	163
8MI3	2	2	1	485	479	211.88	218.08	153	219
8MI4	2	2	1	443	454	165.81	149.86	308	373
8MI5	2	2	1	457	458	263.70	266.80	326	201
8MI6	2	2	1	358	359	238.90	233.14	567	584
8MI7	2	2	1	435	410	234.76	234.32	171	183
8MI8	2	2	1	526	510	194.75	192.24	365	362
8MI9	2	2	1	462	453	191.06	190.76	545	510
8MI10	2	2	1	358	434	250.26	199.03	196	285

IDNumber	Gender (1=F, 2=M)	Time Condition (1=3, 2=8, 3=15)	Sound Given (1=1st Trial, 2=2nd Trial)	Flight Time (ms) Sound	Flight Time (ms) No Sound	Peak Force (N) Sound	Peak Force (N) No Sound	Time to Peak Force (ms) Sound	Time to Peak Force (ms) No Sound
8MII1	2	2	2	466	500	153.32	154.05	288	145
8MII2	2	2	2	404	384	261.05	257.80	179	187
8MII3	2	2	2	504	489	240.81	205.97	93	127
8MII4	2	2	2	455	448	223.39	225.16	189	455
8MII5	2	2	2	507	497	301.94	270.35	114	204
8MII6	2	2	2	502	465	166.55	171.71	252	337
8MII7	2	2	2	427	422	163.30	163.60	285	412
8MII8	2	2	2	465	452	152.96	149.13	319	378
8MII9	2	2	2	475	479	202.87	207.15	422	374
8MII10	2	2	2	431	457	208.33	177.33	178	190
15MI1	2	3	1	658	662	161.23	177.47	453	143
15MI2	2	3	1	427	459	201.25	207.89	309	318
15MI3	2	3	1	567	574	228.12	221.62	259	303
15MI4	2	3	1	440	430	188.10	195.49	331	331
15MI5	2	3	1	468	424	167.43	185.00	477	684
15MI6	2	3	1	355	391	205.68	211.29	419	272
15MI7	2	3	1	483	492	135.84	131.26	521	413
15MI8	2	3	1	523	549	229.30	229.89	526	339
15MI9	2	3	1	442	396	227.53	223.98	102	252
15MI10	2	3	1	463	430	221.18	222.65	373	512
15MII1	2	3	2	511	511	145.75	155.76	212	283
15MII2	2	3	2	437	463	176.24	173.10	154	205
15MII3	2	3	2	427	436	217.64	198.00	233	310
15MII4	2	3	2	450	445	255.43	210.55	363	386
15MII5	2	3	2	353	357	280.39	279.80	161	239
15MII6	2	3	2	485	511	148.68	146.02	212	217
15MII7	2	3	2	485	466	182.79	189.29	614	808
15MII8	2	3	2	495	446	166.99	159.02	470	428
15MII9	2	3	2	419	430	194.01	205.53	397	380
15MII10	2	3	2	463	452	192.83	195.34	204	207