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CONTENT

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"WHAT IS WORSE THAN DEATH?": EXPERIENCE OF CRITICAL EVENTS AMONG PHYSICIANS

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ABSTRACT

Background. It is noticeable that doctors' avoidant behavior while dealing with emotional consequences of critical events not only lowers physician's quality of sleep (Kahn, Sheppes, & Sadeh, 2013), brings them less satisfaction with the results of their work (Gleichgerrcht & Decety, 2013), but also worsens medical care as they provide poorer services related to the patient (Austin Saylor, & Finley, 2017; Meier, Back, & Morrison, 2001). The lack of scientific publications shows that this topic is underresearched and relevant. The purpose of the study is to reveal physicians' experience of critical events.

Methods. Five practicing physicians of anesthesiology-reanimatology and surgery participated in the qualitative part of the research. The data was collected using semi-structured interview and processed using inductive thematic Braun & Clarke (2006) analysis.

Results. Qualitative analysis revealed the complicated experiences in a physician's workplace, which doctors described as: taking responsibilities in the presence of a patient's death, the risk of burnout and negative emotions experienced after a critical event. The analysis also emerged techniques used in dealing with emotions after critical events and consequences of the latter in one's personal life.

Conclusions. The study revealed that physicians in their work environment come across difficulties such as risk of burnout, balancing between formal and informal communication with patients and emotional strain which is caused by facing a patient's death. Doctors tend to cope with negative emotions that emerge during critical events using various methods, but the most elucidated technique was the avoidance to deal with emotions. Analysis also revealed that experiences, gained through medics' work, modify their attitude towards life and death and change the emotional connection between a physician and his relatives.

Keywords: critical incident, death, medical mistake, avoiding emotions, medic.

INTRODUCTION

Research shows that three quarters of physicians have experienced more than one critical incident during the past five years of practice (Van der Ploeg, Kleber, & Dorresteijn, 2003). Critical incidents described by medics are mostly related to mistakes, complications, and severe haemorrhage (Cohen, Leykin, Golan-Hadari, & Lahad, 2017), deaths of young people and children, suicide, encounters with dead bodies at work (Van der Ploeg et al., 2003; Venytė, 2008; Zdanavičienė, 2013) and unsafe situations.

As it is stated in Conservation of Resources Theory (COR), encounter with critical incidents causes loss of personal resources (self-esteem, sense of security, energy becomes lower). Such encounter not only causes stress, but also aggravates individual's ability to deal with critical incidents. The said theory also maintains that many people are capable of quick recovery of the lost resources and thus deal with the stress created by the critical event. On the other hand, another, Terror Management Theory, that explains what causes and suppresses negative emotions at the moment of encounter with death and realization of mortality, states that culture and relation to the society helps people to manage anxiety and fear that arise when confronted with death. It is also noticed that self-confidence and maintaining close relations with other people helps an individual when he or she is encountered with death of another person (Vance, 2014).

In various surveys physicians describe deaths of their patients as critical events (Peters et al., 2013A; Stasiulytė, 2015; Whitehead, 2014). It has been established that, independent of the fact that medical personnel know the deceased, medics experience mourning reactions when a patient dies (Jambois-Rankin, 2000). The results of surveys show that when a physician encounters the death of a patient, the grief of the medic aggravates if the medic had established emotional connection to the patient, had intensely interacted with him or her (Granek, Krzanowska, Tozer, & Mazzotta, 2012; Meier et al., 2001; Whitehead, 2014;) or if the physician identifies himself or his close ups with the deceased (Whitehead, 2014; Meier et al., 2001).

As qualitative studies reveal, after encounter with death of a patient medical personnel experience such negative emotions as fear, anxiety, hopelessness (Stasiulytė, 2015; Whitehead, 2014), and stress (Barauskaitė, 2013). The said physicians are also inclined to reflect the loss, look for their personal fault in the incident (Stasiulytė, 2015; Whitehead, 2014). It has been observed that medics resign with the death of an older person more easily because such death is accepted as natural biological process (Stasiulytė, 2015). Physicians also mention delivery of bad news to the patient as emotionally difficult and stressful or even critical event (Blažytė, 2012).

A tendency has been observed that physicians seek detachment and avoid handling emotions that arise after encounter with critical events (Blažytė, 2012; Stasiulytė, 2015). It has also been established that doctors try to suppress such emotions by relaxing passively or taking care of their own health or health of people close to them (Blaževič, 2016). The other aspect related to the experience of critical events by physicians is the aim to give a meaning to it (Blažytė, 2012; Stasiulytė, 2015). When confronted with death, doctors are inclined to reflect about inevitability of death (Blaževič, 2016; Blažytė, 2012; Stasiulytė, 2015) and feel the desire to discuss the situation with colleagues thus finding comfort and resignation with death (Stasiulytė, 2015).

Medics who encounter pain and suffering of other people are exposed to greater risk of experiencing long-term consequences of such encounters to their psychical health and well-being (Melvin, 2015; Zdanavičenė, 2013). It has been observed that doctors who are not capable of recognition and description as well as control of their own negative emotions caused by a critical event are more inclined to experience emotional exhaustion, are more detached emotionally (Gleichgerrcht & Decety, 2013; Venytė, 2008), they provide poorer services related to patient health care (Meier et al., 2001, Austin et al., 2017), experience less satisfaction with the results of their work (Gleichgerrcht & Decety, 2013) and lower quality of sleep (Kahn et al., 2013).

Summarizing it can also be maintained that critical events in doctor's work are conceptualized as encounters with deaths of patients, critical conditions, suicides. Two theories explain consequences of such encounters – Conservation of Resources and Terror Management. Physicians in their work quite often encounter critical events that they describe as care of the patient in critical condition or the death of a patient. Such incidents affect medics emotionally, but physicians avoid dealing with emotional reactions that have arisen.

The **purpose of the study** was to reveal experiences of critical incidents among practicing Lithuanian doctors.

Objectives of the study:

1. Reveal emotional experiences that physicians encounter during and after critical events.
2. Discuss ways of dealing with emotions that medics apply.
3. Reveal influence of critical incidents on personal life of physicians.

METHODS

Participants of the study. Five practicing physicians participated in the study, all of them were Lithuanians, and their native language was Lithuanian (see Table 1.) All participants were physicians having no less than five year working experience. The criterion of five years was selected having in mind that individuals will already have been adapted at work and discussions of the subject will cause the minimal risk of secondary trauma. The sufficient working practice to experience critical incidents has also been considered, i.e., five years should be a safe period of time when physicians will have something to share. It was soughed for participants' specializations to be closely related with critical conditions, such as anesthesiology or surgery. Considering that commonness of unique experiences of the participants is very important in qualitative studies other selection criteria were not applied.

Table. **Demographic characteristics of participants of the qualitative study**

	Linas*	Agnė*	Karolis*	Greta*	Ignas*
Specialization	Physician reanimatologist-anesthesiologist	Physician reanimatologist-anesthesiologist	Physician surgeon-traumatologist	Physician therapist (working in an emergency room)	Physician neurosurgeon

Note. *For the purpose of anonymity, names of the participants have been changed.

The participants were invited to take part in the study using the method of snow ball. The method was chosen considering the fact that the research aimed to involve participants who had experience that was relevant to the issue (Žydžiūnaitė & Sabaliauskas, 2017). Also, it was more likely that the involved individuals would be motivated to share their experiences. Those participants of the research who responded were motivated to participate, reflective, open, therefore the material obtained during the interview was deep and contained sentimental material.

The Process of the Study. Bioethics Committee of the Lithuanian University of Health Sciences on June 6, 2017 issued permission (No. BEC-SP(M)-135) to perform the study. The research was conducted from July 6, 2017 till August 14, 2017. Meetings with the participants were held at convenient for them time in a convenient location. Meetings with three participants were conducted in their workplace as they requested. One participant was interviewed in a quiet café, so there were no disturbances, another participant requested to have a meeting at his home. All five interviews were conducted smoothly.

Before the interview, the participants of the study were acquainted with the conditions of the survey (anonymity, possibility to withdraw from the study, usage of the interview material, etc.). After receiving consent of the participant to take part in the research he or she was requested to fill in the informed consent form. The interview lasted from 13 to 39 minutes.

Transcription was done by the researcher, therefore it was possible to stay close to the material and the experience of participants and get deeper understanding of the phenomena. Transcription and review of the transcribed material also allowed to easier perform division of the available material into notional units and codes.

Analysis of the Data. Analysis of the data was performed applying inductive theme analysis of Braun and Clarke (2006). The aim of theme analysis is to determine, analyze, and present themes that emerge when studying a particular phenomenon. The method of theme analysis was selected because it allows the researcher to distance from the theoretical field and construct themes based only on the obtained information (Braun & Clarke, 2006). The said method is also a widely used and described in literature on method of qualitative data analysis, which does not require thorough theoretical background of the researcher or accumulated significant experience in the field of qualitative studies (Žydžiūnaitė & Sabaliauskas, 2017).

To ensure validity of the research, data were also reviewed by a consultant and scientific advisor, accuracy of formulations was discussed, they were adjusted to reflect experiences of the participants of the study more accurately. The researcher also kept a diary during the entire period of qualitative study.

RESULTS

When performing thematic analysis, it was sought to distinguish themes that were common to the majority of the participants of the research and described the experience of critical events in the work of a physician. Three major themes emerged: complicated experiences in the work of a physician, techniques of dealing with emotions after the critical event, and consequences critical events has for one's personal life. Theme analysis results are presented in a scheme (see Figure).

1. Complicated experiences in the work of a physician

All physicians who participated in the research distinguished experience of complicated situations that has long lasting effect. The participants stated that critical events and work with patients in critical condition have become an ordinary part of their work, but the necessity to draw the line between formal and informal contact with patients always remains. However, all physicians admitted that when confronted with critical event they experience negative emotions. Medics also talked about taking responsibility when the patient dies and the danger of professional burnout that arises because of enormous workload. Each of the subthemes is discussed in more detail below.

1.1 Critical events and critical conditions – ordinary part of work. The participants distinguished that, despite the fact that people of many professions encounter mistakes in their work, errors made by physicians are equivalent to critical events because of the damage they cause: "*<…> it looks like a critical incident. (Hm) though I do not know if a failure could be attributed to a critical incident. (Hm) in other words, if someone suffers because of my ... actions.*" (Linas, 2). The participants of the study also indicated that they often encounter patients in critical condition, therefore they consider critical events to be a part of their everyday professional life: *"In that sense, no, well [critical incidents] should be (sighs), well, I say, it is work and it must be done, in the sense, you must have such attitude <...>"* (Ignas, 24). One of the participants of the study emphasized that with the work experience a person gets used to critical events when it seems that there is nothing that could surprise: *"<...> may be it sounds rude when half of a person's head or body is missing, it means nothing to me (hm), this does not affect me (hm), I feel no pain, I have seen all that and I do not know what new could be in it."* (Karolis, 82).

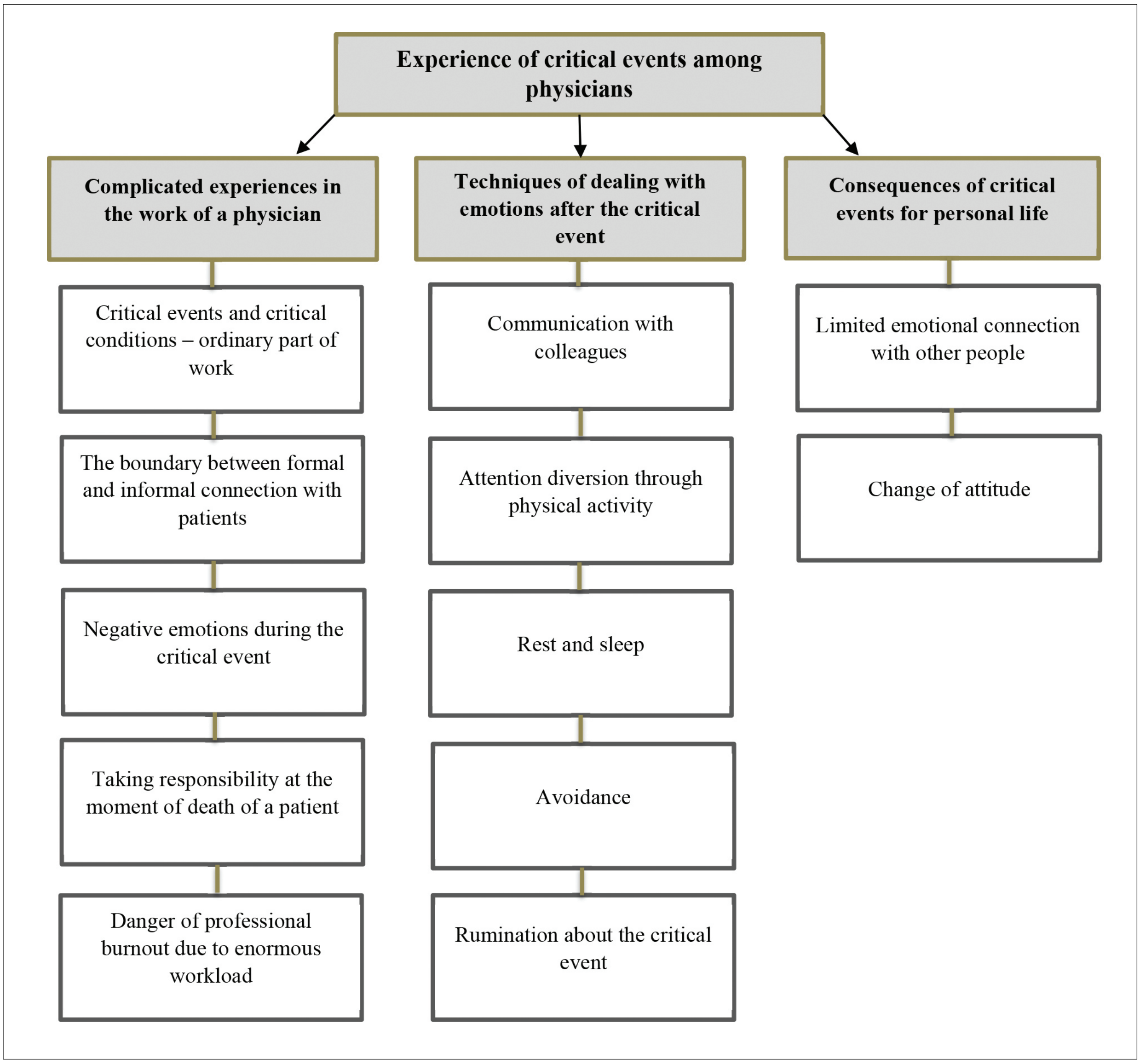

Figure. **Results of thematic analysis: Major themes and subthemes**

1.2. The boundary between formal and informal connection with patients (5/5). The problem of contact with patients in the work of a physician emerged during the interview. The participants of the research told that with some patients they maintain closer contact than with the others: *"In that sense, I say, a certain connection with the patient emerges; somehow this happens with some patients, but does not happen with the others. You just feel more pity about some while about others (smiles) I cannot say that I do not feel sorry, but I do not."* (Linas, 97). Physicians also talked about the fact that critical events, when death is imminent, and patients are young cause greater sorrow: *"<...> older age [patient], but not the sudden deterioration, (inhales) and there he was well and still can be well, and then you care more (silently). That concern, you care equally about the one and the other, but that concern you feel deeply in the latter case."* (Agnė, 43–44). However, one of the participants claims having learned to feel no emotions towards the patient and says he is using it as a safety mechanism: *"(pause, ponders). Those as I say that I that I would something empathize with each in that sense further <...>".* (Ignas, 17). On the other hand, the internal suffering of a physician when observing a dying patient who suffers from pain emerged: *"But, well, Lithuanian law does not let us help to depart. (Hm) Only to make the departure easier. <...> Well, then you make it easier for him and for yourself by giving, well, medication. Some makes him sleepy, some relieve pain, some makes him lose consciousness, say, the same morphine."* (Agnė, 72–75).

1.3. Negative emotions during the critical event (5/5). When speaking about emotions during the critical incident all participants of the study admitted that they experienced certain feelings – anger, guilt, anxiety. The anger of medics, which arises because of insufficient help was particularly obvious: *"(pause, tries to suppress tears) At that time? (hm). (inhales) At that time perhaps the greatest irritation was because I cannot get help that I had been expecting from the surrounding personnel."* (Agnė, 8–9). Some medics admitted that critical event causes anger, which is mixed with the feeling of guilt: *"<...> maybe you feel some guilt when you think that perhaps you have done something wrong. <...> Maybe you feel some anger (hm) that perhaps you should have tried harder, maybe you had something more <...>, so, it's anger>"* (Linas, 78–79). Medics also have admitted that they feel anxiety when confronted with the critical event, which arises because of time limitations and insufficient information about the general condition of the patient: *"Yeah, that anxiety is caused (hm) that that you have short time to make that that person should survive. <...> And that lack of time there causes that anxiety."* (Greta, 41). Medics told about feelings of self-reproach and guilt after the critical incident with unsuccessful outcome: *"<...> such musing, <...> pity arises a bit, <...> a bit of self-accusation <...>, but, well, it's a short signal and that's all."* (Karolis, 47).

1.4. Taking responsibility at the moment of death of a patient (5/5). All physicians who participated in the research shared the suppressing experience when they have to witness the death of a patient. They emphasized that such encounter with death is the most critical part of their work: *"That is, say, the most critical in our work perhaps is the death (hm) of a patient. <...> what is worse than death?"* (Linas, 4–5). The participants of the study said that, when the condition of the patient is particularly complicated, death quasi frees from suffering, but death to the medic himself causes ambivalent feelings – it both saddens and cheers because sufferings of another person are over: *"<...> then you think that the other person is relieved. (hm) Well, it's possible that sometimes you are happy that the person has peacefully departed, as peacefully as possible. Because at other times, yeah, you see a person so exhausted and used-up that, well, death for him is not the worst outcome."* (Agnė, 66–67). The participants of the study deaths of young people and sudden departures from life distinguished as having the greatest psychological burden to a medic: *"There are such things, and deaths have occurred, say, of young people, (hm) that seem not to have so occurred, but occurred, so, well, such things."* (Ignas, 7).

1.5. Danger of professional burnout due to enormous workload (4/5). The participants of the study also talked about enormous workloads that cause overwork and aggravate their professional activities. They distinguished that striving for financial well-being and wishing to afford more than an average person they are forced to take several jobs: *„<...> nowhere in the world doctors don't have to work two or three jobs. <...>say, after twelve years of studies we wish, well, to live a little better than, well, say some average person <...>"* (Karolis, 64). However, working in several jobs does not leave them time for rest: *" Well, I mean* *that perhaps working at such pace when you don't have a possibility to rest after the night shift [you get tired] <...>"(Greta, 19).* Therefore, to maintain their psychological health, medics are trying to emotionally distance themselves from work: *"Welll (drags) at least I imagine that one should try doing this [to distance from work]. <...> because I say that here for each [patient] here… you will become nuts (laughs)."* (Ignas, 20). Immense workload, specifically, causes overwork and professional burnout that affects many spheres of life: *"They are overworked, burnt out, they come and think that will have to somehow work it off, because they know that after these twenty-four hours they will have to go to another workplace or maybe they will have to go home where, I don't know, maybe a child, mother or someone else is sick, so these problems go on and on and on and here is no time for rest."* (Linas, 117).

2. Techniques of dealing with emotions after the critical event

In conversations with the participants of the study the necessity to deal with emotions that arise after the critical incident emerged. Physicians mentioned communication with colleagues, physical activity, rest and sleep, humor and rumination about the critical experience as techniques for dealing with the said emotions. The subtheme of avoidance to deal with arising emotions was distinguished in particular.

2.1. Communication with colleagues (4/5). The participants of the study named conversations with colleagues as one of the most efficient techniques of dealing with emotions after the critical event. Stories of the physicians showed that the most effective possible help to themselves is discussion of critical experience with a colleague: *"Maximum what you can possibly do is perhaps with co-workers. (hm) To share impressions, to speak out (smiles). Maybe as much (whispers)."* (Agnė, 30). Doctors maintain that after such conversations they feel calmer and relieved: *"Then it seems such, wow, relief (gesticulates), if I did that, (hm) and the other person would have done exactly the same, that means I haven't done anything wrong."* (Linas, 38).

2.2. Attention diversion through physical activity (3/5). Some physicians named active physical actions as one of emotion control techniques. According to them, sport or other activity helps "escaping" from thoughts: *"<...> wanted, well, somehow to forget, to somehow waive thoughts away, it was bicycle, well, to go somewhere to work out <...>."* (Karolis, 85). Medics also attest that they try to ventilate emotions through active actions in a workplace as well, but conditions for that are not always favorable: *"(ponders) Sit ups, some physical activity. Muscle activity. <...> Hm. If there is a possibility to do this."* (Greta, 14). Finally, leaving the home environment was named as a method for dealing with emotions that have arisen: *"<...> maybe even meeting with somebody, simple pastime <...>."* (Linas, 93).

2.3. Rest and sleep (4/5). When speaking about dealing with negative emotions after the critical incident medics noted that sometimes after the working day they experience emotional paleness because of the lack of energy. In such cases they resort to sleep: *"You see the door of your house, see the pillow (laughs) and think: My God, this is it. I mean, everything switches off."* (Karolis, 86). Physicians maintain that when they feel emotionally bad after the critical incident first of all they try to get some sleep: *"So far I have no problems with sleep, so after sleeping I feel somewhat better."* (Greta, 17). Medics also note that any activity that allows to have rest also helps to control thoughts: *"<...> you try, I don't know, to simply rest somewhere, good sleep, rest <...> helps somehow dissipate these thoughts <...>."* (Linas, 92).

2.4. Avoidance (5/5). One particularly distinguished subtheme was related to avoidance of dealing with emotional experience and hiding the said emotions from the surrounding people. Some physicians maintained that their emotions could be easily transferred to colleagues and thus aggravate their work as well as reduce productivity: *"I have them, these emotions, but I have no right to show them to employees as my emotions would impede their work."* (Greta, 10). They also noted that experience of emotions would hinder concentration on work and would increase the risk of mistakes: *"(ponders, smiles) Well, those emotions, I say, well are not many, so that you would start running <...> you are trying to think how in a certain situation what you have to do right (inhales)."* (Ignas, 28). Physicians also talked about absence of emotions when confronted with the critical event, as if clear mind and the necessity to act would limit their emotional expression at that moment: *"When you see that patient everything disappears <...>*

you see only one thing, can you or cannot give him [help], you have to do something. (hm) then at that moment those feelings and emotions are absolutely absent." (Karolis, 40). Finally, trying to avoid emotions related to the health of a patient medics admitted that they seek to distance themselves from the patient and be as little as possible emotionally involved at work: *"So, it's not accidental that we somehow, as [names another person] said, and as I say, build a wall. I can't see, I can't hear, I just do what is needed."* (Linas, 17). It is worth noting that one of the participants of the research admitted that at the beginning of his carrier he did not avoid to deal with emotions with the help of alcohol: *"it seemed to me that this [alcohol consumption] was a way to relax, it's like restarting your brain (hm), well, when you inebriate, everything seems funny, easy <...>"* (Linas, 90–91), but after having noticed the harm it causes he claims he had quit the habit.

2.5. Rumination about the critical event (5/5). All physicians who participated in the research admitted that after critical events with unsuccessful outcome they quite often get stuck into thinking and thoughts about it and look for their own mistakes, though there had been none: *"That perhaps I haven't done something. (hm) though most often in such situations you don't even need to look for those mistakes, <...> but, here, at that moment such first thoughts that something I have done wrongly <...>."* (Linas, 74). Medics also indicated that after the critical condition of a patient they analyze and review their own work: *"Well, what else I could have done, what I have done wrong, what I could have done faster, what I couuuuuld have done differently."* (Agnė, 18). Physicians admit that when they fail to save life they often encounter an "internal executioner" that makes them rethink their own actions: *"if, save God, it happens so that, well, you fail, you know, (hm) that that life, well, it's no fun, then you maybe sit and think <...>."* (Karolis, 43).

3. Consequences of critical events for personal life

All medics who participated in the qualitative study indicated that they feel consequences of critical incidents for their personal life. The said change is characterized by limited emotional contact with relatives or other surrounding people and by change of attitude, which had been developed when they started the clinical practice.

3.1. Limited emotional connection with other people. During the interview physicians talked about limited emotional contact with other people – both with the close ups and colleagues as well as with patients. According to them, to provide quality help to a person they are forced to hide their emotions, and quite often this tendency remains in socializing with people of the close environment: *"<...> that, well, perhaps, say, professionally here some mask is put on <...> (hmmm), well, like you forget to take this mask off that you put on, say, at work, (hm) and maybe it is harder for the surrounding people to decide about my emotional state."* (Greta, 47). Physicians also admitted that after work they encounter unpredictable reaction of relatives to their emotional state: *"(pause) either understand or are angry that you are such. (laughs)"* (Agnė, 57). The consequence of all such difficulties is that medics feel isolated and unable to share their emotional experiences with the surrounding world: "*(sighs) Right now I don't know. If if, say, looking at me if I wanted to tell someone about my feelings, what do I feel, then yes, then it's bad. I don't know/I am unable to tell this to someone* (Linas, 122).

3.2. Change of attitude. When speaking about their working experiences physicians described their changed philosophy of life and attitude towards such natural processes of life as death. When they started their clinical practice they began to view the death as part of life and pay less significance to it: *"<...> just you accept everything in perhaps a more natural way <...>, well, that there is a life circle, (hm) someone is born, someone dies, someone gets ill, someone..."* (Agnė, 82). Medics also states that they have learned to accept some events in life as inevitable: *"<...> if time has come for a person to die, he will die <...>."* (Greta, 51); *"such various situations you see, well, you start to think that in that sense, well, be as it may <...> if something happens, it will have to be so and that's all."* (Ignas, 42). Their attitude towards people close to them has also changed, physicians claim that they have become more attentive: *"<...> you become very cautious. You protect everyone <...>, don't take that, you may choke, don't touch that, you may get burned there <...>."* (Linas, 101). But physicians agree that due to their work they have become tougher, the work has hardened them: *"<...> they perhaps may harden me. (hm) Harden and maybe next time in the same situation I maybe,* *I don't know, I will feel somewhat braver <...>."* (Karolis, 118).

Thus in summary it may be stated that physicians at their work encounter several difficulties, such as the need to balance on the verge of formal and informal contact with the patient, danger of professional burnout because of the workload and psychological burden that is caused by encounter with the death of a patient. Physicians also note that in their work they often encounter critical incidents, which they view as a normal part of their work and which cause a lot of negative emotions. As to the negative emotions that arise after critical events, physicians named several ways of how they handle them – sleeping, diverting attention by active actions, socializing with colleagues, and ruminating about the situation. However, during the interview the aim of doctors to avoid emotions and dealing with them became the most obvious. Finally, it was revealed that critical incidents affect physicians' their attitude towards life and death and connections with other people, which become emotionally poorer.

DISCUSSION

As it turned out during the qualitative study, physicians assign deaths of patients and their own mistakes that cause complications to patient's health to critical incidents. These results conform to the data in the literature, which reveals that both Lithuanian and foreign medics mention deaths of patients as the most critical incidents in their work (Blažytė, 2012; Jambois-Rankin, 2000; Peters et al., 2013A; Stasiulytė, 2015; Whitehead, 2014). It is also observed in the studies that medical personnel claims having enough information, which allows to adequately communicate with the dying patient but communicating with relatives of the dying person causes stress, and physicians estimates their ability in this area as poorer (Peters et al., 2013B). It has turned out that quite often the most critical incident is not the death of a patient itself, but inadequate emotional reaction of relatives that is affecting the physician.

All participants of the study spoke about the experience of the death of a patient and emotions that arise upon the encounter with it. They indicated that upon the encounter with the critical event such emotions as anger, guilt and anxiety arise. These results add to the data obtained in other studies, which show that besides the mentioned emotions physicians quite often experience fear and hopelessness (Stasiulytė, 2015; Whitehead, 2014). In scientific studies it is also observed that it is easier for medics to accept the death of an older person, which seems to be "natural" (Stasiulytė, 2015). These results are supplemented by data obtained in the present study. One of the participants of the research told that deaths of young people and such deaths that are unexpected or a given development of the illness is not common are the most critical experiences that shock the most. All participants of the study also spoke about painful experiences when, after having established emotional connection with the patient, it was particularly difficult for them to accept his death. Physicians told that quite often they experience pain and internal suffering that has been caused by the scene of a patient dying in pain. One participant of the study told about ambivalent feelings that arise when a suffering person finally dies. She admitted feeling relief, which is mixed with sadness. The obtained data in the present study supplement the available scientific literature. Studies find that when a doctor establishes contact with the patient, communicates with him or her often or identifies himself with him or her or identifies his close relatives with the said patient in case of death of the patient the physician's mourning aggravates (Granek et al., 2012; Meier et al., 2001; Whitehead, 2014).

In literature when describing techniques of dealing with emotions that arise in the critical incident it is distinguished that physicians after the critical incident are inclined to ruminate and ponder about critical incidents (Stasiulytė, 2015; Whirehead, 2014), take rest and relax by engaging into physically passive activity (Blaževič, 2016), communicate with colleagues (Stasiulytė, 2015), and avoid dealing with emotions as well as to distance themselves from them (Blažytė, 2012; Stasiulytė, 2015; Van der Ploeg et al., 2003). These dealing with emotions techniques were also distinguished by medics who participated in the research and supplemented them by choosing physical activity as a technique of dealing with emotions. The aim of medics to avoid dealing with arising emotions was the most obvious. Participants of the study maintained that to properly perform their work and to prevent the felt emotions from affecting their colleagues they are forced to deny or distance themselves from the felt emotions, not enter into very close contact with patients or colleagues. On the other hand, when striving to distance themselves they feel left alone with their feelings.

Those experiences when medics feel lonely and unwanted leave trace in their personal lives. Participants of the study indicated that their work as physicians has changed their connection with close ups. Physicians said that because of the need to distance themselves from emotions at work they do not feel capable of both recognizing the experienced emotions and communicating with people who are close to them. During the interview it also became obvious that critical events have changed their attitude towards death and life itself – all participants of the study claimed having realized the inevitability of some events and viewing death as a natural part of life. The same tendency was observed in other studies which acknowledged that encounter with critical events makes physicians ponder about the fragility of life and inevitability of death, and this changes their world view (Blaževič, 2016; Blažytė, 2012; Stasiulytė, 2015). Thus they try to give a sense to life and create basis for something, which is out of their control (Blažytė, 2012; Stasiulytė, 2015). Therefore, data of the present qualitative study closely correlate with and supplement results of other studies.

CONCLUSIONS

1. Medics name death of patients and experiences of their own mistakes that generate the whole spectrum of difficult, negative emotions to them as critical incidents. Medics also have to navigate between formal and informal relationship with patients, they feel responsibility at the moment of death of a patient, and all these experiences as well as big workload increase the risk of professional burnout of physicians.
2. Physicians deal with emotions that arise during the critical incident applying such methods as active actions, conversations with colleagues, rest and sleep as well as rumination about the critical incident. However, the aim of medics to deny and to distance themselves from experienced negative emotions has emerged as the most obvious.
3. Critical incidents leave trace in the personal life of physicians, which they feel through poor connection to people close to them and through the change of attitude towards death and life.

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THE IMPACT OF EXERCISE TRAINING IN THE TREATMENT OF DRUG ADDICTION. THE ROLE OF CHANGES IN NEUROTRANSMITTERS

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ABSTRACT

Background. Dopamine and serotonin including are among neurotransmitters involved in addiction to drugs such as the methamphetamine, which suffered cause major damage. This study aimed to investigate the effect of exercise training in the treatment of drug addiction with respect to the changes in neurotransmitters).

Methods. In this study, English and Persian databases including Magiran, SID, Google Scholar, PubMed and Scopus were searched, using keywords such as Exercise, Neurotransmitter, Health Treatment and Patient Addiction. Related articles published during 1986–2017 were assessed. Prevalence of depression in diabetic patients, as well as the relationship between depression and different variables including age, sex, and marital status, was evaluated. This study presents a review of research that has examined the effects of exercise training on drug addiction.

Results. Regular physical activity as aerobic and resistance training resulted in a significant increase in circulatory levels of serotonin and dopamine.

Conclusion. Based on the results achieved by literature analysis and reliance on its major findings it can be concluded that physical activity and exercise training can have an effect on the circulatory levels of both neurotransmitters, such as serotonin and dopamine in addicted people to drugs, and it can also be a helpful factor with respect to the considerations in the treatment of addiction and as well as physical and mental improvement of addicted people.

Keywords: addiction, exercise, health, neurotransmitter, treatment.

INTRODUCTION

Addiction is a chronic disease that requires long-term treatment. Drugs have been used to reduce the intake and prevent the return to drugs, but these methods were not suitable (Hosseini, Alaei, Naderi, Sharifi, & Zahed, 2009). Most addicts tend to change the drug-dependent lifestyle, but there are many problems in the treatment phase that cause recurrence and withdrawal from the treatment period (Ravndal & Vaglum, 1998). For this reason, addiction has been introduced as an acute and reversible problem (van den Brink & Haasen, 2006). Unfortunately, the main problem in the treatment of addicts, even in the long term of cleanliness, is their high rate of relapse (Yan & Nabeshima, 2009). Also, the withdrawal of treatment and re-use of drugs is associated with more negative consequences, such as the likelihood of high consumption of drugs, greater dependence on substances, the use of various drugs, increased criminal behavior and the imposition of additional costs on health and treatment networks (Veilleux, Colvin, Anderson, York, & Heinz, 2010). Drug abuse also affects the body's systems, including the respiratory system and the cardiovascular system, but most of its work has been observed to be mostly effective on the central nervous system, the auto nerve and the digestive system (Le Moal & Koob, 2007). Drug abuse damages the normal functioning of the brain reward cortex (Gardner, 2011). In the early stages of addiction, when the of drug use begins, dopamine in the reward path (for example, the nucleus accumbency, abdominal tangent area and the cerebral cortex) creates incentives for drug use (Koob & Volkow, 2010). Drug use, including psychostimulants, alcohol, nicotine, hallucinogens, cannabinoids and opiates, the amount of dopamine in the nucleus accumbens has increased (Yoshimoto, McBride, Lumeng, & Li, 1992). Blocking this pathway can disrupt the prescription of drugs in particular psychological stimuli (Chang, Sawyer, Lee, & Woodward, 1994).

Drug abuse is a disease that caused by affecting the brain and, the behavior and disorder in several central neurotransmitters. The most important of these systems are dopaminergic and serotonergic systems. Knowledge about the activities of neurotransmitters and proprietary affected by the drug can help treatment (Giannini & Slaby, 1989). Dopamine is produced at the dopaminergic axon terminal (Sadock, Sadock, & Levin, 2007), which has a very important role in controlling motivation, learning positive and negative things, choosing actions for good things and avoiding bad things (Bromberg-Martin, Matsumoto, & Hikosaka, 2010), regulating movement, feeling, cognitive motivation and feeling of enjoyment (Greenwood et al., 2011). Dopamine function also ends with two general ways of reabsorption and decomposition. Serotonin is a monovalent neurotransmitter that is synthesized in gastric mucosal membrane cells and central nervous system cells in the presence of tryptophan, an essential amino acid species. This hormone plays an important role in the regulation of the nervous-hormonal system, mood modification, appetite, sleep, physiological activity, and effective cognitive activity in learning and memory. Serotonin is stored after being produced inside the germs until it is released by the action potential of the neuron. The synaptic effect of serotonin ends up through its reabsorption into the presynaptic terminal by the carrier molecule in the plasmid membrane (Sadock et al., 2007). Physical activity, and in particular, sports training, has the ability to can be used in both the first and final stages of the addiction process as a non-prescriptive adjuvant therapy and has secondary health properties (for example, prevention of obesity and secondary diseases such as diabetes). Physical activity and sports activate the same system in the brain that drugs use achieved through the increase of dopamine and its receptors (Greenwood et al., 2011). These effects may also be helpful in reducing the effects of drug abuse and reducing the vulnerability of drug use (Guezennec et al., 1998). Increasing physical activity or exercise training is accompanied by a decrease in cardiovascular disease and type 2 diabetes, high blood pressure, some cancers, and in general, the decrease of death risk (Kraus, 2010). Regular aerobic exercise like continuous or intermittent walking can decrease the weight (Alizadeh et al., 2013; MJ & MA, 2011). Resistance exercise can also decrease body fats and modify the risk factors (Tresierras & Balady, 2009). Endurance exercise leads to some physiological adaptations, such as the increase of oxidative enzymes, capillary density, the number of mitochondria, maximal aerobic power and the efficiency of cardiovascular system (Tarpenning, Hawkins, Marcell, & Wiswell, 2006). In contrast, resistance exercise can lead to the increase in muscle mass, adaptive proteins and accordingly the increase in muscle strength (Portegijs et al., 2008). When doing long-term aerobic exercises, big muscular masses are used, but when doing resistance exercises, more body parts are involved and it seems that the effects caused by them are different. It has also been shown that resistance exercises and the increase in muscle mass can increase the responses to blood glucose (Braith & Stewart, 2006). Strength enhancement is a result of simultaneous *recruitment* of more motor units, which causes modification of the contraction and increases the ability of muscle to generate force. Training has the ability of increasing the preventive impulses or even opposing it and it can allow the muscle to gain higher levels of strength. Therefore, it is possible to gain strength through decreasing nervous inhibition (Issurin, 2005). Moreover, another strength generating factor is the contact levels of actin and myosin cross bridges. The higher the contact in the cross bridges, the more the level of strength can increase (Luo, McNamara, & Moran, 2005). Endurance increase occurs by the increase in capillary density, the concentration of muscle myoglobin, the number and size of mitochondria and the oxidative enzymes in the body. One of the most important adaptations of endurance exercise is the increase in capillaries surrounding each muscle fiber (Hermansen & Wachtlova, 1971). Endurance exercise increases the number of muscle fibers in any muscle and certain cross-sectional area of muscle. Therefore, blood flow in the muscles, gas exchange, waste materials and nutritious materials increase. These changes are accompanied by adaptations to the oxygen delivery system, which causes the improvement in the oxidative system and endurance (Smith & Fernhall, 2011). Therefore, the purpose of this study was to investigate the effect of exercise training in the treatment of drug addiction from the standpoint of changes in neurotransmitters.

METHODS

The present study was conducted in search of texts in Persian and English informational databases such as Magiran, Google scholars, SID, PubMed Scopus, with the keywords of exercise, neurotransmitter, health, treatment, addiction related to 1986 to 2017. It is focused on the effects of exercise on drug addiction treatment in the aspect of changes in neural mediators. These neural mediators include serotonin and dopamine. All the studies that were not focused specifically on the effects of exercise and drug addiction (from a neural mediator changes point of view) were entirely omitted. The study looks at research on the effects of exercise training on drug addiction in the human and animals with focusing on the neurotransmitter. The findings of the articles are presented in a table with a summary of human and animal research on the effects of various exercises and training on neurotransmitters and addiction-related factors in drug addicted individuals and animals.

RESULTS

Based on our search, eight human studies on the effects of different exercises on neural mediators and the factors affected by drug addiction in addicts and also 12 animal studies on the effects of various exercises on neural mediators and the factors affected by drug addiction in addicted animals done between the years 1986 to 2017 were applied in this study. All the studies which were not specifically focused on the effects of exercise and treatment of drug addiction (from the neural mediator aspect) were omitted from the present study. Reviewing the studies on the effects of different exercises and training on neurotransmitters and factor influenced by addiction in human and animals, regular physical activity as an aerobic and resistance training can lead to significant increases in circulatory levels of serotonin and dopamine (Table 1 and 2).

Components of a workout:

A) Warm-up: At least 5–10 minutes of relaxation and stretching exercises (mostly static stretching exercises).

B) Training: At least 20–60 minutes aerobic, resistance and combination training with frequencies of 2 to 3 sessions per week.

C) Cool-down: At least 5 minutes of static stretching or low-intensity respiratory cardiac activity (such as walking).

The warm-up phase should include at least 5–10 minutes of static stretching and relaxation along with slow running. Warm-up is a transitional period that allows the body to adapt to the physiological, biomechanical and bioenergy conditions required during exercise. Also, warm-up expands the range of motion and can reduce the risk of injury. If the goal is to increase cardio-respiratory endurance, aerobic exercise, sports or resistance training, especially in long-term or repetitive activities, it is best to start with dynamic cardio-respiratory activity in the warm-up phase and then stretching movements. The main activity phase should include aerobic exercise, resistance, flexibility, or sports activities. After the training period, the cool-down period begins, which includes light and slow aerobic activity and stretching (with a pause) for 5–10 minutes. The goal is to cool-down, gradually recover heart rate, blood pressure, and removals of byproducts and metabolites when performing the main activity (Ferguson, 2014; Garber et al., 2011).

DISCUSSION

Amphetamine or cocaine can release normal neurotransmitters too much or prevent the normal recycling of chemicals in the brain. This disruption creates a very intensive message and ultimately the communication paths get disordered (Ahmadi et al., 2005). Consistent use of narcotic drugs by stimulating compromising mechanisms creates short-term and lasting changes in the function of neurons and opioid-sensitive neural networks. Creating tolerance, dependence and sensitivity are examples of compromise mechanisms (Williams, Christie, & Manzoni, 2001). These changes make the addicted people stay vulnerable many years after discontinued use (Nestler, 2001). These enduring changes in the brain and the interaction of opioid drugs and synaptic formability in various brain regions contribute to the onset of recurrence

Table 1. **Summary of animal studies on the effects of various training on neurotransmitter and addiction related factors**

Authors (years)	Title of study	Subjects	Type of exercise or training	Results
1. Chaouloff, Laude, & Merino (1986)	Amphetamine and α-methyl-p-tyrosine affect the exercise-induced imbalance between the availability of tryptophan and synthesis of serotonin in the brain of the rat.	Rat	Run	Control of 5-HT synthesis in the brain with the availability of tryptophan is altered during exercise, and the increased activity of central catecholamines is effective in such a change. The activity of dopamine in the brain can affect brain serotonin responses during exercise. In this study, there was a large amount of dopamine in areas where serotonin levels increased.
2. MacRae et al. (1987)	Endurance training effects on striatal D 2 dopamine receptor binding and striatal dopamine metabolite levels.	Rat	6 months of endurance training	Exercise can modify a number of DA sites and DA metabolism in young adult animals. Aerobic exercises increased dopamine levels. The concentration of dopamine DA and D2 in young runners increased significantly.
3. Dey, Singh, & Dey (1992)	Exercise training: significance of regional alterations in serotonin metabolism of rat brain in relation to antidepressant effect of exercise.	Rat	one hour high intensity swimming and long-term exercise (4 weeks swimming, 6 days per week)	An acute exercise session increased serotonin levels in the brain stem and hypothalamus, but did not alter serotonin levels in the cerebral cortex and the hippocampus, while long-term exercise increased serotonin levels in all areas of the brain, and one week after all the last exercise session was still intact.
4. Bequet et al. (2001)	Changes caused by aerobic exercise on glucose and serotonin of brain through microdialysis probes in the hippocampus of rats; combined effects of glucose.	Rats	Aerobic exercise	During the exercise, synthesis and metabolism of noradrenalin, serotonin and dopamine increase and are applicable in treatment of disease with lack of dopamine. These results show that exercise significantly changes the level of serotonin which was modified dramatically through injecting glucose.
5. Cosgrove, Hunter, & Carroll (2002)	Decreased self-administered cocaine in the model of running the mice: sex differences	Rat	Run	A model of voluntary running in mice and possibly voluntary exercise in humans may be a substitute for the reduction of drug abuse as a natural reward.
6. Langfort et al. (2006)	The effects of endurance exercise on local metabolism of serotonin in brain during the first level of detraining in female rats.	Female rats	Six weeks of endurance training	The increased of serotonin caused by aerobic exercises was reported.
7. Vučcković et al. (2010)	Exercise elevates dopamine D2 receptor in a mouse model of Parkinson's disease: in vivo imaging with [18F] fallypride.	Rat	Treadmill	As a result of aerobic training, the levels of dopamine increased.
8. Lynch et al. (2010)	Aerobic training reduces cocaine search behavior and related neuronal compatibility in the cerebral cortex.	Rat	Aerobic training	Exercise training the same system in the brain, which seeks to consume drugs like cocaine through increased dopamine and its receptors. Therefore, exercise can be a protective way of preventing the return to drug use and can result in neuro-hormone compliance.
9. Alberghina et al. (2010)	Reponses of peripheral serotonergic to exercise in horses.	Six horses	Aerobic exercises	Aerobic exercise increases the level of serotonin
10. Fontes-Ribeiro et al. (2011)	May exercise prevent addiction?	Rats adult male	Continuous training include a treadmill running with increase intensity for eight weeks	Physical training according to a specific daily schedule can prevent amphetamine addiction in similar situations used in this study.
11. O'dell et al. (2012)	Effect of exercise on the improvement of damage caused by methamphetamine uses on dopaminergic and serotonergic terminals.	Amphetamine addicted mice	Seven days exercise	They concluded that 7 days of exercise in mice caused significant changes in the serotonin and dopamine levels and their receptors in the brain.
12. Goekint et al. (2012)	Sprinting stimulates dopaminergic neurotransmission in rats but shows no effects on brain-derived neurotrophic factor.	Rats	60 minutes of running on treadmill	The level of dopamine increases due to aerobic exercises.

Table 2. **Summary of human studies on the effects of various training on neurotransmitter and addiction related factors**

Authors (years)	Title of study	Subjects	Type of exercise or training	Results
1. Valim et al. (2013)	The effects of aerobic and stretch training on the level of serum serotonin (5HT) and its primary metabolite (5HIAA).	22 women	Aerobic (walking) and stretching exercise	The significant increase in the level of 5HT and 5HIAA caused by aerobic exercises.
2. Vafamand et al. (2013)	The effect of eight weeks aerobic training on serotonin and dopamine levels.	30 addicted people	Aerobic training	Regular aerobic training affected the levels of serotonin and dopamine in addicted women and increase cardio respiratory endurance.
3. Robertson et al. (2015)	The effect of exercise training on D2 / D3 receptors in methamphetamine users during behavioral therapy.	19 addicted people	3 days a week, 8 weeks of exercise	Exercise can increase the amount of dopamine in the experimental group.
4. Arazi et al. (2016)	The effect of training on blood serotonin and dopamine levels and physical fitness factors of opium addicts in rehabilitation period.	34 addicts to opium	Aerobic exercise is usually 2 to 3 sessions per week and each session is 20 to 30 minutes walking exercise	Training is small but regular and walking can increase serotonin and dopamine levels.
5. Arazi et al. (2016)	Aerobic training can increase serotonin levels.	20 people addicted to methamphetamine	Eight weeks aerobic training	The effect of 8-week aerobic training on plasma serotonin levels and the depression rate of methamphetamine addicted men in rehab.
6. Arazi et al. (2017)	Changes in blood levels of endorphins, serotonin and dopamine and some physical health variables following a period of aerobic training on men with a history of methamphetamine addiction.	30 people addicted to methamphetamine	Eight weeks aerobic training	Aerobic training can significantly increase blood serotonin, dopamine and endorphins level.
7. Dadvand et al. (2017)	Effect of a course of aerobic training on blood serotonin and endorphins levels and reduction of depression among drug addicted women.	30 drug addicts	Eight weeks aerobic training	Aerobic exercises can increase levels of serotonin and endorphins.
8. Arazi et al. (2017)	Neurotransmitters and cardiovascular responses to aerobic and resistance training in methamphetamine addicts.	10 people addicted to methamphetamine	Aerobic and resistance training	Aerobic and resistance training can significantly increase blood serotonin and dopamine levels.

Table 3. **Recommendations based on aerobic training**

FITT- VP	Recommendations
Frequency	• Equal or more than 5 days per week, moderate intensity exercise, or equal to or more than 3 days per week of intense activity, or a combination of moderate to intense exercise that is equal to or greater than 3-5 days per week is recommended.
Intensity	• In most adults, moderate or high intensity is recommended. • In untrained people, low to moderate activities are recommended.
Duration	• 30-60 minutes a day of activities moderate targeted, or 20-60 minutes per day of intense exercise, or a combination of moderate to intense exercise in a day is recommended in most adults. Exercise less than 20 minutes per day can be beneficial, especially in people who have been inactive.
Type	• Regular and targeted activities that performed with large muscles groups are continuous and rhythmic.
Volume	• The target volume is equal to or greater than 500–1000 set-minutes per week recommended. • Increase the number of steps taken, equal to or more than 2000 steps per day to achieve the daily step equal to or greater than 7000 steps per day is useful. • In people, who are not interested or those who cannot reach the recommended amount of activity, doing less exercise can be helpful.
Pattern	• A exercise is conducted on a day-to-day basis (continuously) or in equal periods more than 10 minutes per day to reach the duration and amount of the desired exercise.
Progress	• Gradual progress in the amount of exercise, frequency and severity (to maintain) the achievement of the intended exercise is acceptable.

Note. Ferguson, B. (2014). ACSM's Guidelines for Exercise Testing and Prescription 9th Ed. 2014. *The Journal of the Canadian Chiropractic Association, 58*(3), 328; Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I.-M., . . . Swain, D. P. (2011). American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise. *Medicine and Science in Sports and Exercise, 43*(7), 1334–1359.

Table 4. **Recommendations based on resistance training**

FITT - VP	Recommendations
Frequency	• Each major muscle group should be given 2-3 times per week.
Intensity	• Severity of 1-RM 60–70% (moderate to high intensity) to increase strength in beginners and moderately active people. • 1RM intensity 40–50% (very low to low) to increase strength in beginner elderly. • The severity of the 1-RM 40–50% (very low to low) may be beneficial for improving the strength of the beginner's limb, which begins the resistance training program. • Intensity below 1-RM 50% (low to moderate intensity) to increase muscle endurance • 1-RM intensity (20–50%1RM) for increased power in elders.
Duration	• No specific training period has been identified for the effectiveness of the workout.
Type	• Resistance exercises are recommended with the main muscle groups. • Multi-articular exercises that affect more than one muscle group and on the muscles that support and antagonists are recommended in adults. • Single-jointed exercises that involve the original muscle groups can also be included in the resistance training program, typically following multiple muscle exercises of the particular muscle group. • You can use various sports equipment or body weight to do movements.
Repetitions	• 8–12 repetitions recommended for increasing the strength and power of most adults. • 10–15 repetitions recommended for beginners to increase strength and power in middle-aged and elderly people. • 15–20 repetitions are recommended to increase muscular endurance.
Sets	• 4 sets in most adults is recommended to increase strength and power. • Single sets can be particularly effective in beginners and elderly people. • Equal or more than 2 sets are effective in increasing muscle endurance.
Pattern	• The rest intervals are 2–3 minutes between sets of repetitions. • For each muscle group, interval intervals equal to or greater than 48 hours between sessions are recommended.
Progress	• Progressive resistance or more repetitions at any time or increase in the number of sessions is recommended.

Note. Ferguson, B. (2014). ACSM's Guidelines for Exercise Testing and Prescription 9th Ed. 2014. *The Journal of the Canadian Chiropractic Association, 58*(3), 328; Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I.-M., . . . Swain, D. P. (2011). American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise. *Medicine and Science in Sports and Exercise, 43*(7), 1334–1359.

Table 5. **Recommendations based on flexibility training**

FITT- VP	Recommendations
Frequency	• Equal to or more than 2–3 sessions per week; • Stretching exercises are more effective every day.
Intensity	• Stretching to the point of feeling tight or slight (pain threshold)
Duration	• In most adults, static stretching is advisable for 60–30 seconds. • In adult carriages, stretching for 30–60 seconds can have some benefits. • In the case of PNF stretching, 3–6 seconds of light-to-moderate intensity contraction (for example, 20–75% maximum voluntary contraction) followed by 10–30 seconds of auxiliary stretching.
Type	• For each major tendon muscle group, a series of flexible exercise is recommended. • Static stretching (for example, active or inactive), dynamic, ballistic, and PNF stretching are effective.
Volume	• A reasonable goal is to perform a total of 60 seconds of stretching for each stretching exercise**.**
Pattern	• It is recommended to repeat each stroke for 2–4 times. • Flexural activities are effective when the muscle is accompanied by aerobic exercise with low to moderate intensity.
Progress	• Desirable progress is not fully understood.

Note. Ferguson, B. (2014). ACSM's Guidelines for Exercise Testing and Prescription 9th Ed. 2014. *The Journal of the Canadian Chiropractic Association, 58*(3), 328; Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I.-M., . . . Swain, D. P. (2011). American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise. *Medicine and Science in Sports and Exercise, 43*(7), 1334–1359.

(Nestler, 2002). Exercise is one of the effective and cost-benefit methods of addiction. There is a lot of evidence that voluntary sports have self-motivated effects by influencing reward systems (Lett, Grant, Koh, & Smith, 2001). Recent experiences and clinical findings have shown that long-term regular exercise can activate the central opioid system and stimulate endogenous opioid release while increasing the threshold of pain in both humans and animals (Koyuncuoğlu, Nurten, Enginar, & Özerman, 2001). Exercise can be a useful tool in the prevention and treatment of drug dependence (Ehringer, Hoft, & Zunhammer, 2009). Some well-known molecular mechanisms of voluntary exercise include increased neuronal growth, thirst and dendritic growth, the number of presynaptic vesicles, increased neuronal factor derived from the brain, and expression of most genes involved in synaptic plasticity in the hippocampus and Cortex of the brain (Cotman & Engesser-Cesar, 2002). Drug abuse is a major hygiene and health problem that has many social and economic consequences. Commonly used drugs that are being misused include psychotic stimuli such as cocaine, amphetamines and their derivatives. Although it has already proven that mesoporticolimbic dopamine plays a major role in the behavioral responses resulting from the use of these drugs, which includes enhancement and refinement effects, recent studies indicate the involvement of the brain serotonin system in relation to drug abuse (Adlard & Cotman, 2004). Psychosocial stimuli not only inhibit dopamine delivery and increase dopamine release but also inhibit serotonin reuptake and increase it in extracellular space (Filip, Alenina, Bader, & Przegaliński, 2010). Repetitive drug use causes prolonged damage to dopaminergic and serotonergic terminals and reduces serotonin, dopamine, and their synthesis enzymes (Giannini et al., 1989). Exercise, on the other hand, also reduces the damage to monoaminergic terminals (dopamine and serotonin) and increases their levels in the blood. This correlation shows that exercise can have many behavioral and physiological benefits for improving addicted people (O'dell, Galvez, Ball, & Marshall, 2012). There is a relationship between dopamine and all aspects of behavior, such as motor activity, and it has been proven that exercise increases the release and synthesis of dopamine, stimulates neoplasm, improves health, and feels good (Morgan & Malison, 2007). Drug abuse such as amphetamine leads to an increase in the reaction between oxygen, nitrogen and damage to monoammonergic venereal terminals (Fontes-Ribeiro, Marques, Pereira, Silva, & Macedo, 2011). On the other long-term exercises increase the activity of endogenous antioxidant enzymes (Segura-Aguilar & Kostrzewa, 2004). Therefore, aerobic training in this study may be effective in increasing serotonin and dopamine levels. In prolonged aerobic exercises, free tryptophan is increased in plasma and enters the brain cells, which results in the synthesis of serotonin and its distribution in the bloodstream (O'dell et al., 2012). Another mechanism that increases serotonin and dopamine is a neurotrophic growth factor. Aerobic exercise induces an increase in in vivo endothelial growth factor and may contribute to injuries due to angiogenesis stimulation and a direct effect on the neurotrophic growth factor, which leads to the reconstruction and repair of damaged terminals of monoammonergic dopamine and serotonin (Morgan et al., 2007). Evidence suggests that short-term and long-term exercises lead to changes in many neurotransmitter systems (Lynch, Peterson, Sanchez, Abel, & Smith, 2013).

Accordingly, physical activity and exercise are used as a contributing factor in the treatment of drug use disorders and the improvement of the status of addicted people (Zschucke, Heinz, & Ströhle, 2012). In their study, Chaouloff et al. (1987) concluded that brain dopamine activity could be effective on brain serotonin responses during exercise. In this study, a large amount of dopamine was observed in the areas where serotonin levels increased (Chaouloff et al., 1987).

The effects of endurance training on the binding of astryatal dopamine D2 receptors and the levels of dopamine stearate metabolites were investigated by MacRae, Spirduso, Cartee, Farrar, and Wilcox (1987). This study examined the effects of six months of endurance training on young adults on the relationship between the uniformity of D2 levels and its metabolite in stratium and the dependence and concentration of dopamine DA and D2 in the samples. The dopamine DA and D2 concentrations of young runners significantly Increased (MacRae et al., 1987).

Dey, Singh, and Dey (1992) investigated the effect of a swim and a long-term exercise (4 weeks swimming, 6 days a week) on serotonin levels in different brain regions. An acute exercise session increased serotonin levels in the brain stem and hypothalamus, but did not alter serotonin levels in the cerebral cortex and hippocampus, while long-term exercise increased serotonin levels in all areas of the brain and one week after the last sporting session remained the same (Dey et al., 1992). Bequet, Gomez-Merino, Berthelot, and Guezennec (2001) investigated the changes caused by aerobic exercises on glucose and serotonin of the brain received by microdialysis probes in rats' hippocampus. It was observed that in the first minute of exercise the amount of serotonin changes by glucose alterations, but it follows a different pattern during the resting time and after 30 minutes of rest, and the level of serotonin increases to the maximum level. These results show that exercise training changes the level of serotonin which is dramatically modified by glucose injection (Bequet et al., 2001). Cosgrove, Hunter, and Carroll (2002) showed that a model of voluntary running in mice and possibly voluntary exercise in humans could be a substitute for reducing drug abuse (Cosgrove et al., 2002). In another study, Langfort et al. (2006) examined the effects of endurance training on tryptophan and serotonin and the main acid metabolism in different parts of female rats' brain, at the end of the last training session and 48 hours after that. Endurance exercises were done for six weeks and finally the results showed an increase in serotonin level due to aerobic exercises (Langfort et al., 2006). Vučcković et al. (2010) showed that aerobic training increased dopamine levels. Lynch et al. (2013) showed that exercise activated the same system in the brain that seeked to consume narcotics such as cocaine by increasing dopamine and its receptors (Lynch et al., 2013). Therefore, exercise can be a protective way to prevent the return to substance use and cause hormonal neurological adaptation (Vučcković et al., 2010). Alberghina, Giannetto, and Piccione (2010) conducted a study to determine the effects of exercise on plasma tryptophan and blood free serotonin in six healthy horses. The findings showed that aerobic exercises can cause the increase in serotonin levels (Alberghina, Giannetto, & Piccione, 2010). Fontes-Ribeiro et al. (2011) aimed to investigate the effect of exercise in the mechanism of amphetamine addiction in experimental rats on adult male rats. The results of the study showed that regular exercise overlaps with drug abuse, for this reason, the effect of exercise on the dopaminergic system and a change in dopamine is observed (Fontes-Ribeiro et al., 2011). O'dell et al. (2012) examined the effect of exercise on improving the damage of serotonergic terminals in addicted mice and concluded that exercise training in rats caused significant changes in serotonin levels and their receptors in brain regions (O'dell et al., 2012). Goekint et al. (2011) reported that high-speed running stimulates dopaminergic neurotransmission in rats' hippocampus, but does not affect BDNF. The purpose of the aforementioned study was to investigate the effect of sprint exercise training on monoaminergic neurotransmission and BDNF. The results showed that 60 minutes running increased dopamine secretion in rats' hippocampus (Goekint et al., 2011). Also, in a study by Valim et al. (2013), aerobic and stretch training increased serum serotonin (5HT) and its primary metabolite (5HIAA). Vafamand, Kargarfard, and Marandi (2012) investigated the effect of eight weeks of aerobic training on serotonin and dopamine levels in 30 addicted women in Isfahan Central Prison. The results indicated that aerobic training significantly increased serotonin and dopamine levels in the experimental group compared to the control one (Vafamand et al., 2012). Robertson et al. (2016) aimed to investigate the effect of the training program on the amount of dopamine research on addicted men and women. The study showed that exercise increases can the amount of dopamine in the experimental group (Robertson et al., 2016). Arazi, Mollazadeh, Dadvand, and Davaran (2016) conducted a study to investigate the effect of exercise on serum levels of blood serotonin and dopamine and the physical fitness factors of opium addicts during rehabilitation course (Arazi et al., 2016). In another study, the effect of seven weeks of combined exercise (aerobic-resistance) on blood levels of serotonin and dopamine and physical fitness factors on men who were addicted to methamphetamine in the rehabilitation period. The researchers concluded that training increased dopamine and serotonin levels in the experimental group (Arazi, Damirchi, & Poulab, 2016). Arazi and Dadvand (2017) investigated the effects of eight weeks of aerobic training on plasma serotonin levels and the rate of depression of men methamphetamine addicts in the rehabilitation period. The results indicated that aerobic exercise significantly increased serotonin levels in the experimental group compared to controls (Arazi & Dadvand, 2017). Another study conducted to investigate the changes in blood levels of endorphins, serotonin and dopamine and some physical health variables following a period of aerobic exercise training on men with a history of methamphetamine addiction.

Finally, the results of the study showed an increase in serotonin, dopamine and endorphin levels after eight weeks of aerobic exercise (Arazi, Rafati, & Dadvand, 2017). Dadvand and Daryanoosh (2017) investigated the effect of a course of aerobic training on serotonin and endorphin levels and depression of drugs addicted women in 30 drugs addicted women. The results of this study showed that aerobic training can increase blood serotonin and endorphin levels in the experimental group compared to control (Dadvand & Daryanoosh, 2017). The effects of aerobic and resistance training on neurotransmitters and cardiovascular responses, investigated by (Arazi, Dadvand, & Fard, 2017). The results of the study showed an increase in blood serotonin and dopamine levels after aerobic and resistance training (Arazi et al., 2017).

CONCLUSION

In summary, based on the findings of controlled animal and human studies, it was determined that exercise training with increasing activity of endogenous antioxidant enzymes and neurotrophic growth factors can lead to reconstruction and repair of damaged terminals of monoaminergic dopamine and serotonin. It suggests that these training can help with the improvement of physical and hormonal status along with drug therapy and can be useful as a complementary therapeutic mechanism through effective mechanisms that can promote and improve health. Therefore, in order to increase the neurotransmitters level of serotonin and dopamine, addicts can perform these type of training (aerobic, resistance, and flexibility) with considerations during treatment.

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EFFECTS OF AN EIGHT-MONTH EXERCISE INTERVENTION PROGRAMME ON PHYSICAL ACTIVITY AND DECREASE OF ANXIETY IN ELEMENTARY SCHOOL CHILDREN

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ABSTRACT

Background. The World Health Organization recommends children to participate in sufficient PA by engaging in moderate-to-vigorous physical activity for at least 60 min daily per week. Schools are important settings for the promotion of children's physical activity. Through commuting, breaks, and physical education lessons they provide regular opportunities for children to be active.

Methods. The experimental group included 36 girls and 34 boys aged 6-7 years old. Their mean weight and height were 24.3 ± 0.9 kg and 1.25 ± 0.11 m for the girls, and 29.3 ± 0.6 kg and 1.33 ± 0.09 m for the boys. The control group included 35 girls and 33 boys aged 6–7 years old, attending the same school. Their mean weight and height were 22.3 ± 0.7 kg and 1.24 ± 0.1 m for the girls, and 28.4 ± 0.7 kg and 1.36 ± 0.07 m for the boys. The methodology of innovative physical education classes was based on the DIDSFA model (dynamic exercise, intense motor skill repetition, differentiation, physical activity distribution in the classroom). *The evaluation of physical activity*. Children's Physical Activity Questionnaire (Corder et al., 2009) was used. It was also based on the Children's Leisure Activities Study Survey (CLASS) questionnaire. *The measurement of anxiety* – the methodology of Reynolds and Richmond (1994).

Results. The post-test of the experimental group boys (1320.24 MET, min/week) was to analyse average physical activity in comparison with the girls of the experimental group (840.60 MET, min/week). Statistically significant difference was found during the analysis of average MET per boy (1390.45 MET, min/week) in comparison with the girls (880.27 MET, min/week, $p < .05$). The results of the somatic anxiety in EG (5.54 ± 1.18 points) before the experiment and after it showed that after the intervention programme somatic anxiety in EG was 5.08 ± 1.09 points. This demonstrates lower levels of depression, seclusion, somatic complaints, aggression and delinquent behaviour ($F = 4.895$, $p < .05$, P = 0.550).

Conclusion. It was established that properly construed and purposefully applied complex of the eight-month exercise intervention programme for elementary school children led to statistically significant changes in the dependent variables: increased physical activity and decreased anxiety for the experimental group.

Keywords: physical activity, anxiety, innovative physical education classes, primary education.

INTRODUCTION

Research has shown that participation in school physical education (PE) may affect students' motivation to engage in physical activity because it has the potential to provide both positive and negative experiences for the student population (McKenzie, 2007). Schools are an ideal setting to implement physical activity programs targeted at youths' learning and intellectual abilities. Physical inactivity has been identified as an independent risk factor for coronary heart disease (CHD) with the risk for CHD increased nearly twofold for persons who are physically inactive (Berlin & Colditz, 1990). Reports have attributed 22–30% of cardiovascular deaths, 20–

60% of cancer deaths, and 30% of diabetes deaths to sedentary lifestyles and dietary factors (McGinnis & Foege, 1993), given that physical inactivity is a pervasive problem causing both critical health issues and placing a huge cost on global economy (Finkelstein, Trogdon, Cohen, & Dietz, 2009). When children experience positive outcomes from their involvement in physical activity, they can also be expected to remain involved in physical activity in adulthood (Dishman et al., 2005).

Physical activity and exercise have positive effects on mood and anxiety and a great number of studies describe an association of physical activity and general well-being, mood and anxiety (Ströhle, 2009). Physical inactivity may also be associated with the development of mental disorders: some clinical and epidemiological studies have shown associations between physical activity and symptoms of depression and anxiety in cross-sectional and prospective-longitudinal studies (Abu-Omar, Rütten, & Lehtinen, 2004). Although physical education lessons are often seen as funny and enjoyable, they may also trigger negative feelings such as anxiety because of their comparative, competitive and evaluative nature (Barkoukis, Tsirbatzoudis, Grouios, & Rodafinos, 2005). Anxiety in physical education classes can be manifested through cognitive (e.g. negative thoughts), bodily (e.g. alteration in muscle tension), and information processing (e.g. worry and attention disruption) symptoms (Barkoukis et al., 2005). On other hand, low physical activity levels are associated with increased prevalence of anxiety (Stubbs et al., 2017).

The purpose of this study was to establish the effects of a 8-month exercise intervention programme on physical activity and decrease of anxiety for first grade students

METHODS

Participants. According to the SVIS data base statistics (http://www.svis.smm.lt/), the number of first grade students in year 2017/2018 was 30.126 in total (14.609 of girls). All in all, 384 first form students had to be tested. This study was only observational and therefore a smaller number of respondents were selected.

The school was randomly selected from primary schools in Lithuania. With the approval of the parents, the time and place of the examination were agreed with the school administration in advance. The study took place in 2017 from September to November in four Lithuanian general education schools that had primary education and primary education classes. The time and place of the study, with the consent of the parents, were agreed upon in advance with the school administration.

The experimental group included 36 girls 34 boys aged 6–7 years old. Their mean weight and height were 24.3 ± 0.9 kg and 1.25 ± 0.11 m for the girls, and 29.3 ± 0.6 kg and 1.33 ± 0.09 m for the boys. The control group included 35 girls and 33 boys aged 6-7 years old, attending the same school. Their mean weight and height were 22.3 ± 0.7 kg and 1.24 ± 0.1 m for the girls, and 28.4 ± 0.7 kg and 1.36 ± 0.07 m for the boys.

In the present research, we used a pre-test/post-test experimental strategy, which was chosen to avoid any interference with educational activities due to the random selection of children into the groups. The experimental group was under test during eight months. We developed the methodology of innovative physical education classes and created the model of educational factors stimulating pupils' physical activity. We identified relationships between the pupils' physical activities at school and learning achievements. We also prepared the methodical material for innovative physical education classes. The methodology was based on the DIDSFA model (dynamic exercise, intense motor skills repetition, differentiation, reduction of parking and seating, physical activity distribution in the classroom) (Powell, Woodfield, & Nevill, 2016; Buliuolienė, Daukšaitė, Klizas, Klizienė, & Cibulskas, 2017). The girls and boys in the control group attended the same (non-modified) physical education lessons.

The evaluation of physical activity. Children's Physical Activity Questionnaire (Corder et al., 2009) was used. It was also based on the Children's Leisure Activities Study Survey (CLASS) questionnaire, which included activities specific to young children, such as "playing in a playhouse." The original intent of the proxy-reported CLASS questionnaire for 6–7-year-olds was to assess type, frequency, and intensity of physical activity over a usual week.

The evaluation of children's anxiety. The methodology of Reynolds and Richmond (1994) was used (Dewaraja Sato, & Ogawa, 2006; Klizienė, Klizas, Čižauskas, & Sipavičienė, 2018). The Revised Children's Manifest Anxiety Scale (RCMAS) contains 37 items with 28 items used to measure anxiety and an additional nine items that present an index of the child's level of defensiveness. For our study, we were only concerned about the factor analysis of anxiety; therefore, only those 28 items used to measure anxiety were used in this factorial analysis. The RCMAS consists of three factors, 1) somatic anxiety consisting of 12 items, 2) personality anxiety consisting of eight items, and 3) social anxiety consisting of eight items. The results are estimated as follows: 1) somatic anxiety (up to 6.0 points – high somatic level, from 5.9 to 4.5 points – average somatic level, from 4.4 to 1.0 point – low somatic level); 2) personality anxiety (from 2.0 to 2.5 points – low personality anxiety level, from 2.6 to 3.5 points – average personality anxiety level, from 3.6 to 4.5 points – high personality anxiety level); and 3) social anxiety (to 5.5 points – high social anxiety level, from 5.4 to 4.5 points – average social anxiety level, from 4.4 to 3.3 points – low social anxiety level). Cronbach's alpha coefficient for subscales ranged from .72–.73.

Mathematical statistics. The arithmetic mean (x) and the average standard deviation (SD) were determined for comparison. Differences between different genders, age and physical fitness were estimated using one-factor dispersion analysis (ANOVA). The relationship between variables was calculated on the basis of the correlation coefficient of the Spearman correlation coefficient. Differences between different genders and physical activity were estimated using Mann-Whitney *U* test. The following reliability levels were used for statistical outputs: $p > .05$ – insignificant; $p < .05$ – significant. All calculations were performed using MS Excel and SPSS programs.

RESULTS

Physical activity of 7-year-old children. On analysing the pre-test results of physical activity of the 7-year-old students, it turned out that both the boys (115.05MET, min/week) and girls (90.58 MET, min/week) in the experimental group were physically active during physical education classes ($p > .05$).

The analysis of physical activity types, such as cycling to school and walking to school showed that there were no differences in gender according to MET. In the context of average physical activity,

Table 1. **Physical activity level using the MET method (the pre-test/post-test results of the experimental group)**

Type of physical activity	MET	1 day/min	Days per week	MET (min/week)
The experimental group pre-test				
Boys				
Physical education lesson	3.5	30	1	87.90
Cycling to school	4	0.6	3	20.54
Walking to school	3.3	0	4	0.00
Sports groups (mean physical activity)	6	56	1	1053.84
			On average for one boy	1162.28*
Girls				
Physical education lesson	3.5	30	1	81.58
Cycling to school	4	0.36	3	16.75
Walking to school	3.3	0.85	4	2.50
Sports groups (mean physical activity)	6	56	1	652.11
			On average for one girl	773.94*
Experimental group post-test				
Boys				
Physical education lesson	3.5	30	1	115.05
Cycling to school	4	0.6	3	19.68
Walking to school	3.3	0	4	0.00
Sports groups (mean physical activity)	6	56	1	1185.51
			On average for one boy	1320.24*
Girls				
Physical education lesson	3.5	30	1	90.58
Cycling to school	4	0.36	3	17.50
Walking to school	3.3	0.85	4	25.14
Sports groups (mean physical activity)	6	56	1	707.38
			On average for one girl	840.60*

Note. *$p < .05$ (according to the Mann–Whitney *U* test).

a higher indicator (1053.84 MET, min/week) was detected in the boys of the experimental group in comparison with the girls (652.11 MET, min/week). Statistically significant differences were found in average MET per boy (1162.28 MET, min/week) in comparison with the girls (773.94 MET, min/week) ($p < .05$, Table 1).

The post-test of the experimental group boys (1185.51 MET, min/week) was to analyse average physical activity in comparison with the girls of the experimental group (707.38 MET, min/week). Statistically significant difference was found during the analysis of average MET per boy (1320.24 MET, min/week) in comparison with the girls (840.60 MET, min/week, $p < .05$; Table 1).

Analysing the results of the 7-year-old students' physical activity, it turned out that in the control group, both boys (92.36 MET, min/week) and girls (90.15 MET, min/week) were physically active in physical education classes ($p > .05$) during the pre-test.

The analysis of physical activity types such as cycling to school and walking to school found no differences in gender according to MET. A higher number of the boys in the control group (938.16 MET, min/week) was determined during the analysis of average physical activity compared to the girls of the same group (558.24 MET, min/week). Statistically significant differences were found during the analysis of average MET per boy in the control group (1048.76 MET, min/week) compared to the girls (678.59 MET, min/week, $p < .05$; Table 2).

The post-test results of the boys of the control group (1000.98 MET, min/week) were determined by the analysis of average physical activity in

Table 2. **Physical activity level using the MET method (the pre-test/post-test results of the control group)**

Type of physical activity	**MET**	**1 day/min**	**Days per week**	**MET (min/week)**
Control group pre-test				
Boys				
Physical education lesson	3.5	30	1	90.36
Cycling to school	4	0.80	3	21.18
Walking to school	3.3	0	4	0.00
Sports groups (mean physical activity)	6	56	1	938.16
			On average for one boy	1048.70*
Girls				
Physical education lesson	3.5	30	1	88.34
Cycling to school	4	0.41	3	11.88
Walking to school	3.3	0.48	4	20.13
Sports groups (mean physical activity)	6	56	1	558.24
			On average for one girl	678.59*
Control group post-test				
Boys				
Physical education lesson	3.5	30	1	92.08
Cycling to school	4	0.80	3	24.10
Walking to school	3.3	0	4	0.00
Sports groups (mean physical activity)	6	56	1	1000.98
			On average for one boy	1117.16*
Girls				
Physical education lesson	3.5	30	1	90.15
Cycling to school	4	0.41	3	12.56
Walking to school	3.3	0.48	4	20.23
Sports groups (man physical activity)	6	56	1	585.09
			On average for one girl	708.03*

Note. *$p < .05$ (according to Mann–Whitney U test).

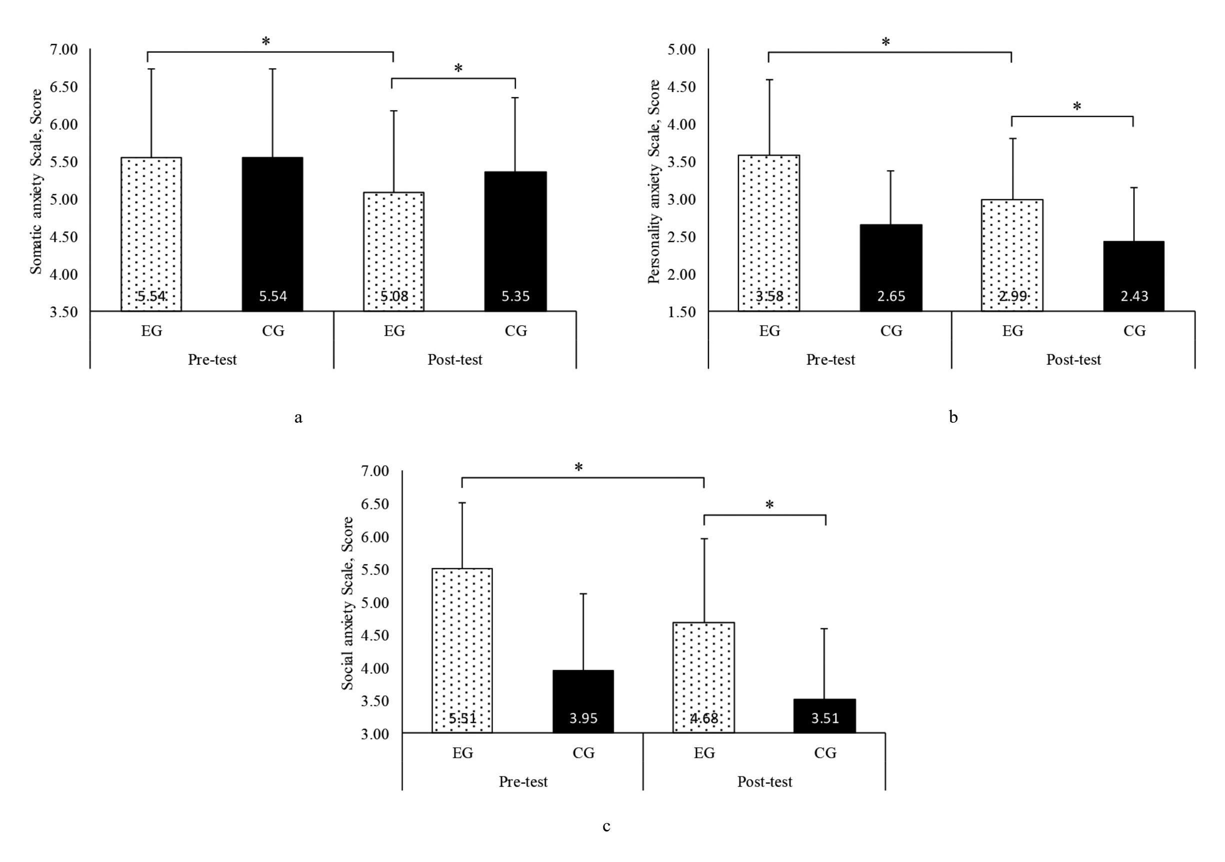

Figure. **The level of elementary school children's somatic anxiety (a), personality anxiety (b), and social anxiety (c) in the pre-test and post-test**

comparison with the girls of the same group (585.09 MET, min/week). Statistically significant differences were found in average MET per boy (1117.16 MET, min/week) in comparison with the girls (708.03 MET, min/week, $p < .05$, Table 2).

Anxiety of 7-year-old children. The study performed at the beginning of the experiment showed that in the pre-test, the level of somatic anxiety of the adolescents in CG (girls and boys) was average (5.54 ± 1.18 points). When exploring the results of the somatic anxiety in EG (5.54 ± 1.18 points) before the experiment and after it, we established that after the intervention programme, somatic anxiety in EG was 5.08 ± 1.09 points. This demonstrates lower levels of depression, seclusion, somatic complaints, aggression and delinquent behaviour (F = 4.895, $p < .05$, P = 0.550; Figure a).

When dealing with the results of the anxiety of personality, we established that in pre-test and post-test, the results of CG students were not statistically significantly different (2.65 ± 0.73 points and 2.43 ± 0.73 points correspondingly, F = 0.138, $p > .05$, P = 0.048). When analysing EG personality anxiety results in pre-test and post-test, we established that after the intervention programme, EG personality anxiety results decreased (3.58 ± 1.00 points and 2.299 ± 0.82 points correspondingly, F = 5.205, $p < .05$, P = 0.598; Figure b).

In the pre-test, the level of social anxiety in CG was 3.95 ± 1.18 points. The post-test CG result was statistically significantly lower (3.51 ± 1.09 points, F = 3.265, $p < .05$, P = 0.667). When analysing the levels of the social anxiety of EG, pre-test and post-test results decreased after the intervention programme (5.51 ± 1.00 points and 4.68 ± 1.27 points correspondingly) and were significantly different (F = 7.038, $p < .05$, P = 0.698; Figure c).

DISCUSSION

It was established that the properly construed and purposefully applied complex of the eight-month exercise intervention programme for first grade students led to the statistically significant changes in the dependent variables: increased physical activity and decreased anxiety for the experimental group.

The main aim of this research was to evaluate a one-year teaching strategy intervention, which supported teachers in increasing children's active learning time during primary physical education classes. Our results indicated that the intervention programme was effective. The goal of a positive youth development perspective is the promotion of healthy physical and psychosocial development in young people. School physical education represents a context that has the potential for promoting positive youth development by helping students acquire life skills and psychosocial as well as behavioural attributes that can transfer to other important domains (school, family, work) concurrently and over the life span (Weiss, 2012). Physical activity has potentially beneficial effects for reduced depression, but the evidence base is limited. Intervention designs are low in quality, and many reviews include cross-sectional studies. Physical activity interventions have been shown to have a small beneficial effect for reduced anxiety, but the evidence base is limited. Physical activity can lead to improvements in self-esteem, at least in the short term (Biddle & Asare, 2011). Strauss, Rodzilsky, Burack, and Colin (2001) found that children spent 75.5% of the day inactive, with a mean $\pm$ *SD* of 5.2 ± 1.8 hours watching television, sitting at the computer, and doing homework. In contrast, only 1.4% of the day (12.6 ± 12.2 minutes) was spent in vigorous activity. Time spent in sedentary behaviours was inversely correlated with the amount of moderate-level activity ($p < .001$) but not high-level activity. High-level physical activity was also associated with improved self-esteem ($p < .05$) (Strauss et al., 2001). Yoo et al. (2016) analysed the effects of a school-based mind subtraction meditation program on depression, social anxiety, aggression levels of 42 elementary school children in South Korea. The research design was a non-equivalent group comparison with pre-test and post-test. The experimental group was given eight weeks of the meditation program. The results showed social anxiety, aggression levels were significantly lowered in the experimental group. This demonstrated that the school-based mind subtraction meditation program could be effective in improving psychosocial and behavioural aspects of mental health in elementary school children. Hollis et al. (2016) found, that the percentage of physical education (PE) lesson time spent in PA ranged between 11.4–88.5%. When measured using direct observation and accelerometers, children spent 57.6 (47.3–68.2) and 32.6 (5.9–59.3)% of PE lesson time in PA, respectively. In our study, we found the same results of both boys and girls being physically active in physical education lessons ($p < .05$).

CONCLUSION

It was established that properly construed and purposefully applied complex of the eight-month exercise intervention programme for elementary school children led to the statistically significant changes in the dependent variables: increased physical activity and physical fitness in the experimental group.

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RELATIONS OF BODY VOLUMINOSITY AND INDICATORS OF MUSCULARITY WITH PHYSICAL PERFORMANCE OF POLICE EMPLOYEES: PILOT STUDY

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ABSTRACT

Background. Activities like running, push-ups and sit-ups may be impacted by a higher body volume and size whether it is due to the amount of fat mass (FM) or skeletal muscle mass (SMM). The purpose of this study was to investigate the differences in physical performance among muscularly developed police employees with higher body mass index (BMI) levels.

Methods. Twenty (n = 20) male police employees were divided in 3 groups by BMI but defined by significantly different skeletal muscle mass index (SMMI): muscular (n = 7, BMI < 25 kg/m^2, SMMI ≥ 13.16 kg/m^2), very muscular (n = 7, BMI = 25–27.5 kg/m^2, SMMI = 13.17–14.10 kg/m^2), and highly muscular (n = 6, BMI > 27.5 kg/m^2, SMMI ≥ 14.10 kg/m^2). Body composition components (FM, SMM, percent of fat mass [PFM], percent of skeletal muscle mass [PSMM], SMMI) were assessed by multichannel bioelectrical impedance. The differences in performance of the 50-meter sprint run (RU50), 1-minute push-up (PU), 1-minute sit-up (SU), and 800-meter run (RU800) between BMI groups were statistically tested by a univariate analysis of variance with a Bonferroni post-hoc test.

Results. Highly muscular participants performed fewer SU than muscular (8.14 repetitions, p = .004) and very muscular (6.42 repetitions, p = .021) participants, and run slower on RU800 test (52.57 s, p = .034 and 51.71 s, p = .038, respectively).

*Conclusion***.** Physical performance may be negatively impacted in highly muscular police employees once BMI gets above 27.5 kg/m^2 and SMMI above 14.10 kg/m^2.

Keywords: body composition, running, push-ups, sit-ups.

INTRODUCTION

Body mass index (BMI) is an anthropometric measure often used as a rough estimate of general health status and as a surrogate measure of body composition in police studies (Boyce, Jones, & Lloyd, 2008; Dopsaj & Vuković, 2015; Kukić & Dopsaj, 2016; Orr, Dawes, Pope, & Terry, 2017). Several studies conducted with police employees have shown associations between BMI and physical performance, injury rate and health status (Dawes Elder, Hough, Melrose, & Stierli, 2013; Dawes, Orr, Siekaniec, Vanderwoude, & Pope, 2016; Deschamps, Paganon-Badinier, Marchand, & Merle, 2003; Gershon, Lin, & Li, 2002; Orr et al., 2017). Although the success in police occupations requires good physical performance (Carbone, Carlton, Stierli, & Orr, 2014; Carlton, Gorey, & Orr, 2016), it may be negatively affected by a higher BMI, over 25 kg/m^2 (Dawes, Orr, Elder, & Rockwell, 2014; Dawes et al., 2016). Therefore, BMI may be an easy and cost-effective method of predicting individuals at risk of lower physical performance on physical fitness tests. However, it is not clear how performance would be affected if the higher BMI was due to a greater skeletal muscle mass (SMM) as opposed to a greater fat mass (FM).

Studies on various athletes of both genders (Dopsaj et al., 2017; Milić et al., 2017) and on police officers (Dawes et al., 2017; Kukic, Dopsaj, Dawes, Orr, & Cvorovic, 2018; Mitrović, Djordjević, Dopsaj, & Vučković, 2015) indicate that better performers normally possess leaner bodies with well-developed muscle mass and low amounts of fats. However, none of these studies investigated the effects of body muscularity on physical performance if the subjects were highly muscular (Dopsaj & Đorđević-Nikić, 2016; Kukić & Dopsaj, 2016; Rakić, Marković, Dopsaj, Mlađan, & Subošić, 2013), with increased BMI, but still with low amounts of fats. Moreover, studies on police officers as standard indications of body composition use simple measures such as body mass (BM), BMI, FM, SMM or measures of FM and SMM in ratio to BM (Dawes et al., 2017; Dawes et al., 2014; Kukić & Dopsaj, 2016; Orr et al., 2017). The flaws of using BMI have been repeatedly reported in literature (Davillas & Benzeval, 2016; Kyle et al., 2001; Provencher et al., 2018; Rothman, 2008), while Kukic et al. (2018) pointed out the possible sources of misinterpretations when using BMI, percent of fat mass (PFM), and percent of skeletal muscle mass (PSMM).

Several studies have identified a BMI's inability to differentiate between body weight induced changes caused by FM and SMM, either over time or due to the effects of exercise and diet programs (Demling & DeSanti, 2000; Kyle et al., 2001; Provencher et al., 2018; Rothman, 2008). For example, Kyle et al. (2001) conducted a study on 433 subjects, aged 18 to 94 years and showed no changes over time in BMI, even though FM and PFM significantly increased, while SMM, PSMM and skeletal muscle mass index (SMMI) significantly decreased. When applied exercise training and a casein-based diet regime, Demling and DeSanti (2000) reported minimal changes in BMI, even though police officers significantly decreased PFM by 8% and increased lean body mass (LBM) by 4 kg. More importantly, a significant correlation (r = .065) was found between the muscle gain and increase in strength measured by chest press, shoulder press and leg extension (Demling & DeSanti, 2000). Furthermore, Provencher et al. (2018) highlighted the potential misinterpretation of obesity prevalence in National Football League (NFL) athletes, whereby obesity rates were 53.4% according to BMI ≥ 30 but only 8.5% according to PFM measures. The reason for this discrepancy in results was due to NFL athletes having high amounts of SMM and low amounts of FM.

The theory of geometrical similarities assumes that all human bodies have the same shape and that, therefore, they differ only in size (Jaric, Mirkov, & Markovic, 2005). This means that all lengths are proportional to a characteristic length measured on a subject (e.g., body height [BH]), and all areas (e.g., SMM) are proportional to BH2 (Jaric et al., 2005; Kukic et al., 2018). Accordingly, BMI could be considered a general indicator of body size but without giving a specific information on the source of the size (Provencher et al., 2018; Rothman, 2008). In contrast, FM, SMM can easily be misinterpreted if used as absolute measures because bigger bodies (taller subjects) may naturally possess a bigger amount of FM or SMM. Finally, PFM and PSMM are in somewhat contrast tissues of human body, meaning that increase in PSMM will lead to decrease in PFM and vice versa (Kukic et al., 2018).

Considering this, whether BMI is high due to the amount of FM versus the amount of SMM may be inconsequential as certain activities like running, push-ups, sit-ups and vertical jump may be impacted by a higher BMI regardless of the subject's body composition (Dawes et al., 2016; Mitrović et al., 2015). Mitrović et al. (2015) showed that increased BMI (over 30 kg/m2) in special unit police officers (assumingly muscular) was negatively associated with a 3000m-run velocity. In contrast, Dawes et al. (2014) also showed a negative association between BMI and 1.5 km running performance and VO2max but in officers with increased amount of FM. Increase in BM typically leads to a lower relative oxygen consumption (Mitrović et al., 2015), while increase in SMM increases the metabolic demands (Bassett & Howley, 2000; Lyons, Allsopp, & Bilzon, 2005), based on the type of applied training (Son, H. J. Kim, & C. K. Kim, 2014). In that regard, if an increased BMI, whether due to an increased FM or SMM, can negatively affect performance, the use of the BMI as an indicator of potential physical performance might gain additional support for its use. In contrast, body-size-independent indicators of muscularity may potentially be more precise than commonly used SMM and PSMM and therefore could be used in associating physical performance to body muscularity. Thus, the aim of this study was to investigate the differences in physical performance among police employees based on their BMI but in relation to their level of muscularity defined by body-size-independent indicator of muscularity. It was hypothesized that the participants with higher BMI levels due to greater muscle mass will perform more poorly in upper-body endurance, sprinting ability and middle-distance running; and that body-size-independent indicator of muscularity will be more precise than SMM and PSMM.

METHODS

This study was an observational, cross-sectional study design, consisting of four mandatory field physical abilities tests and laboratory body composition measurements. The participants' body composition was assessed by a multi-frequency bioelectric impendence, which allowed their FM and SMM to be extracted separately. This way it was precisely defined that all participants possess the same PFM but different degree of muscularity. Once participants completed the physical fitness tests, they were divided in three BMI groups and their physical performance was compared between the groups, assuming that those with higher BMI values will perform lower on physical performance tests. The ethical approval (No. 47015) for this study was obtained from the ethics committee of the Faculty of Sport and Physical Education, University of Belgrade.

Participants. The sample of convenience included 20 healthy, physically active male employees of Abu Dhabi Police who completed the test as a mandatory annual assessment. The sample was divided into three groups relative to BMI (see Table), with all groups having a low PFM < 13% (Riebe, Ehrman, Liguori, & Megal, 2018, p. 472) and above average PSMM > 49.79% (Kukić & Dopsaj, 2016; Rakić et al., 2013). Since all the three groups possessed above average PSMM with statistically different skeletal muscle mass index, they were considered muscular but with different degrees of muscularity. Accordingly, the groups were named as follows: Muscular (*n* = 7), with BMI < 25 kg/m^2, and SMMI ≤ 13.16 kg/m^2; Very muscular (*n* = 7), with BMI = 25–27.5 kg/m^2, and SMMI = 13.17–14.10 kg/m^2; and Highly muscular (*n* = 6), with BMI > 27.5 kg/m^2 and SMMI ≥ 14.10 kg/m^2. The main characteristics of the sample relative to group were: Muscular (age = 29.29 ± 1.82 years, body height (BH) = 182.57 ± 5.35 cm, body mass (BM) = 77.96 ± 7.36 kg); Very muscular (age = 28.57 ± 3.55 years, BH = 182 ± 9.22 cm, BM = 86.73 ± 10.13 kg); and Highly muscular (age = 28.30 ± 3.93 years, BH = 182.67 ± 7.09 cm, BM = 99.28 ± 9.13 kg). All participants were informed about the purpose of the testing data collection and they all signed a written informed consent about the use of data in research purposes. This research was carried out in accordance with the conditions of the Declaration of Helsinki, recommendations guiding physicians in biomedical research involving human subjects (Christie, 2000).

Body composition assessment. Body composition analysis and the four physical performance tests were conducted on a same day, with body composition being measured first. The multi-frequency bioelectrical impendence analysis (BIA) machine InBody 720 (Biospace Co. Ltd, Seoul, Korea) was used for full body composition evaluation. The BIA method has been shown to be a reliable (ICC = 0.97) and valid (*r* = .90 for men and *r* = .93 for women, compared to dual-energy x-ray absorptiometry [DXA]) method when used as a field test (Aandstad, Holtberget, Hageberg, Holme, & Anderssen, 2014). Furthermore, hydration was shown to have a minimal effect on accuracy of BIA in college athletes (Kemble et al., 2010). The body composition analysis was conducted according to previously reported protocols (Dopsaj et al., 2017; Kukić & Dopsaj, 2017). Three direct (BM, FM, and SMM) and 3 indirect measures (PFM, PSMM and SMMI) were chosen for the analysis. It was important to show that the groups were not different by the absolute and relative amount of FM in order to define the whole sample as muscular. PFM and PSMM were chosen as volume-independent variables because they show FM and SMM relative to body weight, while SMMI was chosen because it represents body size-independent SMM, calculated as: SMM (skeletal muscle mass, in kg) • BH^2 (body height, in m), expressed in kg • m^{-2} (Dopsaj et al., 2017; Jaric et al., 2005; Kukic & Dopsaj, 2017).

Assessment of physical abilities. Physical performance was assessed using the official Abu Dhabi police test battery for the annual physical fitness assessment, consisting of the following measures: 50 m sprint run (RU50), 1-min push-up (PU), 1-min sit-up (SU), and the 800 m run (RU800).

RU50: Participants were allowed to rehydrate immediately after the body composition assessment. After a 10-minute warm-up, participants approached the starting line and performed a 50 m sprint run one by one as fast as physically able. One tester was at the start line giving the signals 'ready', 'steady', and 'go'. On the 'go' command, the tester at the start line moved their hand down sharply as a signal for the two testers positioned at the finish line, to start the stopwatch. Mean of two measured times were recorded as a valid result. The same testers assessed each participant individually.

PU and SU: After all participants completed the RU50, they were given 10 minutes rest allowing them enough time to get ready for the PU and SU test. The PU test was conducted first and then, following a 10-minute rest period, the SU test was completed. A trained testing team counted the repetitions. Both tests (PU and SU) were conducted according to previously explained protocols and required participants to perform as many repetitions as possible in 1 minute (Čvorović et al., 2018; Dawes et al., 2016).

RU800: After the SU test, participants were allowed to rest for 15 minutes and were given the opportunity to hydrate before the RU800 test. The test was conducted on a 200 m circuit running track, whereby the participants were instructed to run 4 laps as fast as possible. The time was measured using a stopwatch, with the precision of 1 second.

Statistical analysis. Descriptive statistics (i.e. means and standard deviations (SD)) were calculated using Microsoft excel. To investigate the differences between defined BMI groups, a univariate analysis of variance (One-way ANOVA) with Bonferroni post-hoc analysis was used for all variables. The significance level was set at $p < .05$ a priori. For the ANOVA statistical analysis, SPSS software (IBM software SPSS 20.0) was used.

RESULTS

Physical performance outcome measures, the number of SU performed and the time needed to complete the RU800 were significantly affected by the increased BMI (Table). Descriptive statistics and the ANOVA results (Table) showed that BM was significantly different between the BMI groups, while there were no differences in their BH. Furthermore, significant differences in body composition occurred only in SMM and SMMI, while FM, PFM, and PSMM were the same across the groups, suggesting that participants were significantly different only by the total and relative (hence the quality) amount of SMM.

The Bonferroni post-hoc analysis revealed that significant differences in BM (21.32 kg, $p = .001$) and

Table. **Descriptive statistics for mean and standard deviation for each group, with the ANOVA values for *F* and *p***

Variables	Muscular ($n = 7$) Mean ± SD	Very muscular ($n = 7$) Mean ± SD	Highly muscular ($n = 6$) Mean ± SD	*F*	*p*
Age	29.29 ± 1.82	28.57 ± 3.55	28.30 ± 3.93	0.627	.546
BH (cm)	182.57 ± 5.35	182 ± 9.22	182.67 ± 7.09	0.016	.984
BM (kg)	77.96 ± 7.36	86.73 ± 10.13	99.28 ± 9.13	9.234	.002*
BMI (kg/m^2)	23.96 ± 1.35	23.64 ± 0.32	30.91 ± 1.58	55.824	<.001*
FM (kg)	8.49 ± 2.66	9.83 ± 2.53	11.27 ± 1.85	2.171	.145
PFM (%)	10.91 ± 3.34	11.36 ± 2.56	11.33 ± 1.53	0.062	.940
PSMM (%)	50.88 ± 1.97	51.25 ± 2.20	52.18 ± 1.68	0.732	.495
SMM (kg)	39.70 ± 4.52	44.46 ± 5.49	51.80 ± 4.90	9.551	.002*
SMMI (kg/m^2)	11.88 ± 0.9	13.38 ± 0.60	15.51 ± 0.96	30.791	<.001*
50 m (s)	7.09 ± 0.34	6.89 ± 0.34	7.40 ± 0.47	2.780	.090
PUSH UP (No)	41.43 ± 5.41	43.14 ± 4.34	42.67 ± 2.16	0.297	.747
SIT UP (No)	45.14 ± 2.97	43.43 ± 1.90	37.00 ± 5.80	8.173	.003*
800 m (s)	201.57 ± 13.62	202.43 ± 17.56	254.17 ± 61.56	5.212	.016*

Note. BH – body height, BM – body mass, BMI – body mass index, FM – fat mass, PFM – percent of fat mass, PSMM – percent of skeletal muscle mass, SMM – skeletal muscle mass, SMMI – skeletal muscle mass index, 50 m – a 50 m-sprint run test, PUSH UP – maximal number of push-ups in 1 minute, SIT UP – maximal number of sit-ups in 1 minute, 800 m – a 800 m run test.

SMM (12.10 kg, $p = .001$) existed between the normal and highly muscular groups (Figures 1 and 2).

The most sensitive variable was SMMI since significant differences were shown between all groups (Figure 3). Mean differences between the muscular and very muscular and muscular and highly muscular groups were 1.49 kg/m^2 ($p = .011$), and 3.62 kg/m^2 ($p < .001$) respectively, while the mean difference between the very muscular and highly muscular was 2.13 kg/m^2 ($p = .010$).

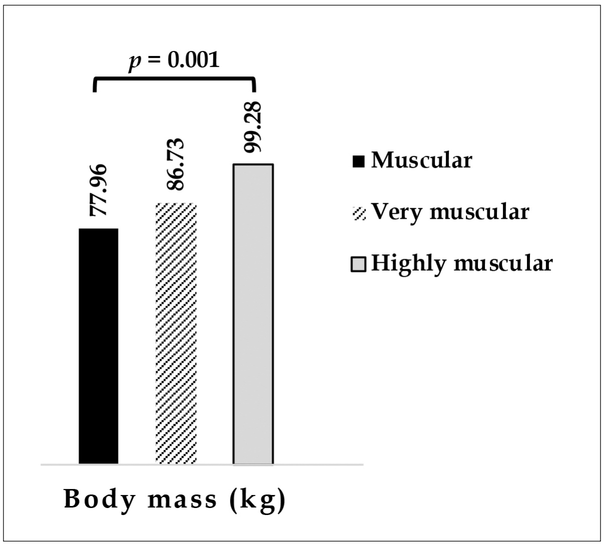

Figure 1. **Differences in BM between the BMI group**

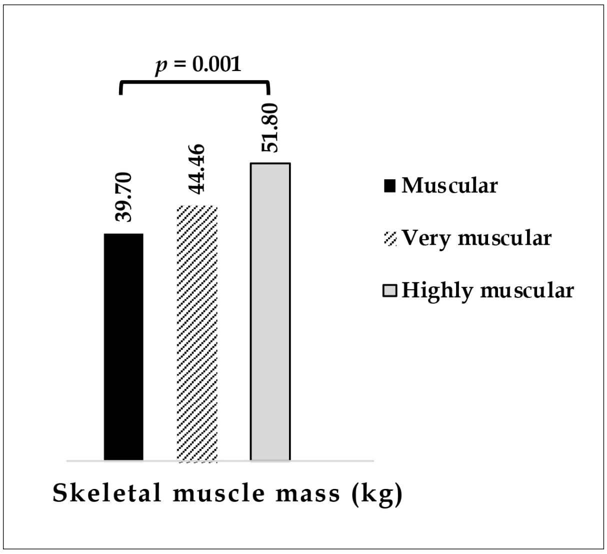

Figure 2. **Differences in SMM between the BMI groups**

The performance of 1-minute SU and RU800 was negatively influenced by higher BMI (Table).

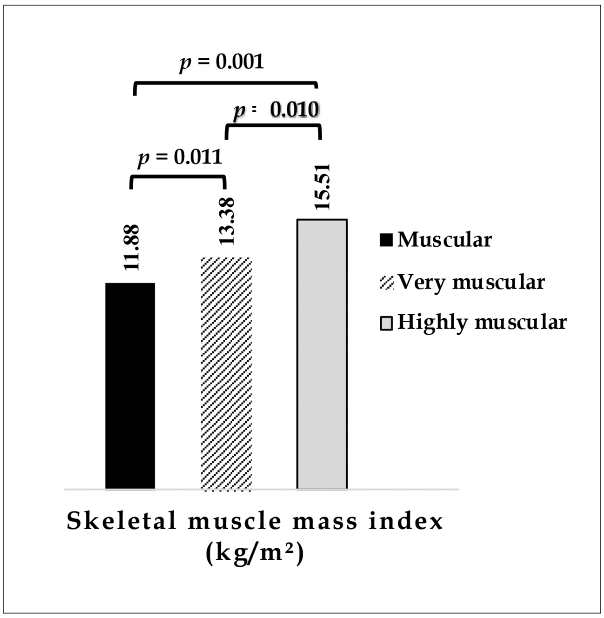

Figure 3. **Differences in SMMI between the BMI groups**

Significant differences were observed between the muscular and highly muscular as well as between the very muscular and highly muscular (Figures 4 and 5). The highly muscular group performed significantly less SU than the muscular and very muscular groups, with the mean differences of 8.14 repetitions ($p = .004$) and 6.42 repetitions ($p = .021$). Similarly, they needed more time to complete the RU800 test than muscular and very muscular groups, with mean lower time of 52.57 s ($p = .034$) compared to 51.71 s ($p = .038$).

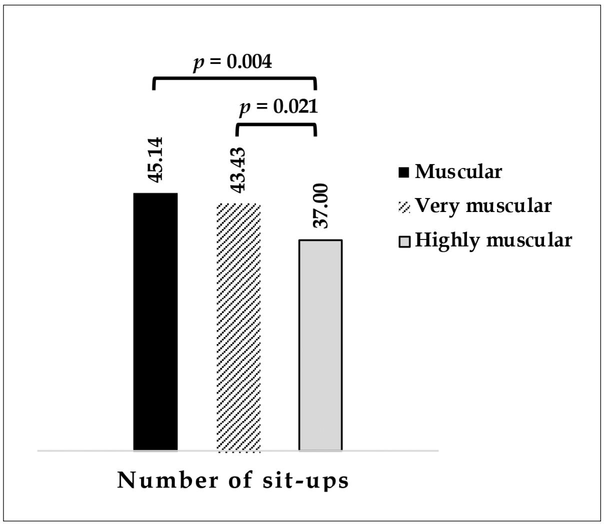

Figure 4. **Differences in number of executed SU between the BMI groups**

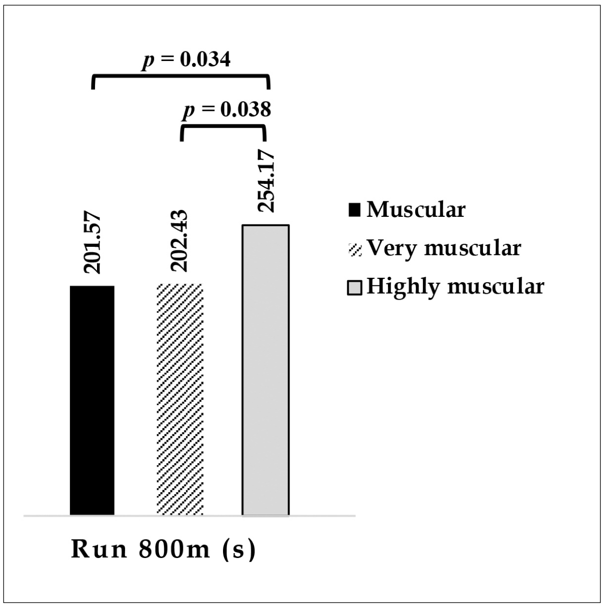

Figure 5. **Differences between the BMI groups in time needed to complete the RU800**

DISCUSSION

The aim of this study was to investigate the differences in physical abilities among muscularly developed police employees with different BMI, and that body-size-independent indicator of muscularity will be more precise than SMM and PSMM.

The main findings of this study suggest that BMI levels of up to 27.5 kg/m^2 if based and SMMI up to 14.10 kg/m^2 may not negatively impact on performance given that the performance was similar to the group with BMI ≤ 25 kg/m^2. However, increasing BMI levels above 27.5 kg/m^2 based on SMMI > 14.10 kg/m^2 (such as body builders) may lead to lower physical performance in SU and RU800. Note that the groups did not differ significantly in PSMM and PFM but they did in SMMI, indicating that the amount of contractile potential on each squared meter of the body size (Dopsaj et al., 2017) was higher respective to BMI group which could be the reason for the equal performance in RU50 and PU (Dawes et al., 2016).

In regard to the RU800 performance, Salvadego et al. (2013) reported lower relative oxygen consumption in participants with increased muscle mass and BMI = 30.1 kg/m^2 (PFM = 12%), relative either to BM or SMM. Thus, a lower performance of highly muscular group in RU800 could be due to decreased oxygen consumption relative to body weight, regardless of body size. Several studies have shown that BMI, FM, and PFM are negatively associated with running performance, estimated VO_2max and occupational task performance (Dawes et al., 2018; Dawes et al., 2016; Mitrović et al., 2015). A study conducted on 72 special force police officers showed negative causal relationship between BMI and running velocity on a 3000m run test and hence aerobic capacity (Mitrović et al., 2015). The authors of this study found that hyper muscular police officers (BMI ≥ 30 kg/m^2, with low levels of FM) run, on average, 0.364 m/s (p = .021) slower than the officers with a normal BMI (BMI ≤ 25 kg/m^2) with a significant prediction coefficient of determination (R^2 = .167, p < .001). Results obtained on RU800 in this study were in somewhat similar since the sample in Mitrović et al. (2015) consisted of officers from a special antiterrorist unit, whose members were physically highly trained, therefore potentially muscularly highly developed officers.

In a load carriage study, Lyons et al. (2005) showed that body composition index, calculated as lean body mass divided by (fat mass + external load), produced a moderate correlation (r = –.52, p < .01) with the metabolic demand of heavy load-carriage. It should be noted that Lyons et al. (2005) showed that the association of SMM and physical performance increases as the task was more dependent on strength and that lean muscle mass should be considered as a selection criterion for load carriage occupations. In that regard, our results support this notation because all participants in this study were muscular above the 50th percentile when compared to the normal population (Kukić & Dopsaj, 2016; Rakić et al., 2013) and similar in musculature to professional combative athletes (Dopsaj et al., 2017). Therefore, they scored highly in strength related tests. However, Lyons et al. (2005) also showed that metabolic demands of the task increased by 51% as the load increased from 0 to 40 kg, while our results additionally suggest that metabolic demands significantly increase once BMI surpass the level of 27.5 kg/m^2 (although highly muscular), leading to a lower performance in RU800.

In other words, highly muscular, or even hyper-muscular police officers, because of the hyper level of muscles as active metabolic consumption mass may have a lower level of metabolic efficiency during the locomotion endurance tasks, such as long running. According to that phenomenon and association of body size and performance (Jaric et al., 2005; Markovic & Jaric, 2004), hyper-muscular body in police should be recognized as a whole body locomotion endurance negative effect. This could lead to a twofold conclusion. Firstly, SMM-induced higher levels of BMI might be an advantage when required to carry a daily occupational load and in sudden physically demanding tasks that require upper body strength (arresting a belligerent, lifting and carrying heavy objects). Secondly, highly increased SMM may become a disadvantage for aerobically demanding tasks (such as chasing suspect, running the stairs, etc.).

Police employees may be required to engage belligerents by using physical force for self-defense or to ensure public safety (Dawes et al., 2018). In that regard, the defensive tactics and arrest control training that mainly consists of martial arts such as judo, wrestling, jiu-jitsu and karate are of high importance for police employees (Dawes et al., 2018). More importantly, the successful application of these defensive and arrest control technics, in real life and unpredictable situations with an unknown opponent, is highly associated with muscle strength (which depends on higher PSMM and SMMI) (Dopsaj et al., 2017). Moreover, Dawes et al. (2016) found positive correlations ($p \leq 0.001$) between estimated LBM and strength tests such as PU, vertical jump, estimated peak power and bench press, suggesting that better PU performance requires a higher estimated LBM, which is partly supported by our results. All three groups from our study were muscularly developed (mean PSMM = 51.43%) and accordingly performed very well on the PU test, with no difference between the groups (although different by SMM and SMMI, Figures 2 and 3). Conversely, a lower performance in SU test achieved by highly muscular group, comparing to very muscular and muscular, is not very clear since it depends on active contractile mass (as in PU test) rather than on endurance. It could be due to the effects of body mass and body size that may occur in performance tests of supporting body weight (Jaric et al., 2005; Markovic & Jaric, 2004), whereby authors suggest that results in tests such as sit-ups should be normalized to BM • –0.33. However, even though highly muscular participants performed lower than muscular and very muscular, they still scored well on SU test comparing to Annual Fitness Assessment, where by 36 sit-ups is a pass mark for the age group 23–30 years (Abu Dhabi Police, Annual Fitness Assessment minimum standards). This again suggests that greater muscle mass leads to a better physical performance, but it also indicate that SMM may become an obstructing factor once a certain amount has been developed. Additionally, increased SMM due to excessive strength training may lead to imbalance between strength and range of motion followed by altered muscle efficacy and increased risk of injuries (Barlow, Benjamin, Birt, & Hughes, 2002; Staron et al., 1990; Tesch, 1988).

CONCLUSION

This study is the first known study to investigate differences in physical performance among police employees with an increased BMI based on higher levels of SMM; and the first one that investigates the precision of SMMI compared to PSMM. Based on the results all three groups showed very good levels of physical performance, although the highly muscular group performed significantly lower than other two groups on RU800 and SU tests. These results suggest that physical performance may be negatively impacted once BMI gets above 27.5 kg/m^2 and SMMI above 14.10 kg/m^2. By having a better understanding of how these factors interact, instructors can be more precise in designing exercise programs, while police employees can benefit by understanding how muscularity can support them in physically demanding tasks, but also how highly developed muscle mass can lead to lower physical performance in other tasks.

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Conflict of interest. There is no conflict of interest for this paper.

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THE IMPACT OF VARIOUS PHYSIOTHERAPY PROGRAMS ON STATIC AND DYNAMIC BALANCE FOR PATIENTS AFTER STROKE

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ABSTRACT

Background. The imbalance in many scientific sources is described as a major disorder in patients with a history of stroke. Often, the importance or disruption of torso control is also indicated on balance impairments. We believe that both physiotherapy programs will have impact on balance however better results on balance tests will be in group which balance training composed of unstable planes. *Research aim was* to measure impact of various physiotherapy programs on static and dynamic balance for patients after stroke.

Methods. To evaluate changes of static and dynamic balance we used: Berg balance test, Tinetti test, PASS test, dynamic gait index, trunk impairment scale, special STREAM movements test for patients after stroke, Mini balance evaluation test for patients after stroke. Training methods of balance were for two different physiotherapy programs: intervention group (basic physiotherapy program with exercises on unstable planes) and control group (basic physiotherapy program with gait training elements).

Results. When evaluating balance, results in both groups were almost equal, which shows that balance was disturbed and there was a huge risk of falls, moreover all patients walked with aid measures. At the beginning of rehabilitation, the average of all balance evaluating tests in both groups scored 16.92 and 15.05. All results were statistically significant ($p < .05$). At the end of research, variations between all test results were defined statistically significant.

Repeatedly evaluating results of both groups at the end of rehabilitation, all test averages were improved: at the beginning, the intervention group average score was 16.92 and after rehabilitation, it was 34.79. For control group results, the average score of all tests was 15.05 and at the end it was 31.90. Summing up, it was established that in both groups balance in rehabilitation period improved.

Conclusions. Physiotherapy programs based on exercises on unstable planes or gait training elements improve balance for patients after stroke. Many studies have confirmed the hypothesis of our study that using unstable planes or walking training methods improve balance, but for a statistically significant change in improving the balance, it will be necessary to use unstable planes.

Keywords: physical therapy, stroke, balance, static, dynamic.

INTRODUCTION

The imbalance in scientific literature is described as a major disorder in patients with a history of stroke. Often, the importance or disruption of torso control is also indicated on balance impairments (Heon & Park, 2017).

According to the results of the study, after stroke, only one of five patients has lived more than 15 years, and lives an inferior life because each year, cognitive and functional abilities are deteriorating, which results in a person becoming less autonomous and more dependent on the surroundings (Crichton, Benjamin, McKevitt, Rudd, & Wolfe, 2016).

Researchers say that torso muscle building and stabilization exercises should be included in the program not only to improve torstile control, but also as an effective method for balancing or walking (Gadhvi, Diwan, & Vyas, 2016).

In a study done by Heon and Park (2017), the findings and results show that torso muscles are very closely related to balance and imbalance disorder, they are included in selective movements to control the centre of gravity while we are standing, during weight bearing and maintaining static and dynamic posture (Heon & Park, 2017).

The findings of other studies have suggested that balance can be improved in the course of walking and exercise in which body weight bearing is required (Duijnhoven et al., 2016). According to scientists, walking improves along with balance (Yelnik et al., 2008).

METHODS

A total of 24 patients were included in the study, 19 of which were women and 5 men that were diagnosed with stroke. All patients participated voluntarily. Patients aged 50 to 80 years. The criteria for patient selection were the following:

1. Conscious, not having perceptions of disability – the result of mini mental test must be > 23 points.
2. The patient could not be completely addicted, the Barthel self-determination index had to be > 62 points.
3. The patient had to be able to move at least within the ward.

The total sample consisted of 24 patients who were randomly divided into two groups: 19 females and 5 males. Group 1: 9 females and 3 males. Group 2: 10 females and 2 males.

The subjects were tested twice: before and after a 7-week course of physiotherapy procedures.

Physical therapy was applied five times a week. The duration of one procedure was 40–45 minutes. Both groups included the same physical therapy structure: introduction, primary, and final, parts and both programs included muscle strengthening, balance training, and general body endurance exercises, but they were applied differently. Exercise of the research group is performed using only unstable surfaces – platforms, mats, balls, and the control group exercises were performed only by incorporating the elements of walking. The study was carried out at a department of rehabilitation in a hospital.

Berg Balance Scale was used for the assessment of static and dynamic balance. Berg Balance Scale is one of the most popular scales that measure functional mobility and balance. It specializes in elderly people and is dedicated to assessing the human potential for safe daily tasks. Tasks vary in complexity: from a sitting position to standing on one leg. This test consists of 14 different tasks, each of which is scored in grades from 0 to 4 points. Score value is as follows: 0 points – a person cannot perform a task, balance is disturbed; 1 point – a person performs a task but needs help; 2 points – performs the task, but only after a few trials, uses minimal help; 3 points – carries out the task independently, with minimal use of his/her body help; 4 points – ability to complete the task.

The maximum score is 56. Assessment of the test results: 0–20 points – the risk of falling is high, 21–40 points – the average risk of falling and 41–56 points – a low risk of falling. Berg and his co-authors found that, after collecting less than 45 points, there is an increased risk of falling.

Balance Assessment Systems Test. This test was developed by measuring 4 out of 6 different balance control systems and helping to tailor rehabilitation methods. This test is recommended by StrokeEDGE as a reliable test to measure post-stroke changes in patient balance. The test evaluates the dynamic and static balance. The test consists of 14 different tasks, each of them is scored from 0 to 2. Score value: 0 points – cannot perform the task; 1 point – performs a task with help; 2 points – performs the task without help.

The maximum score is 28. Assessment of the test results: 0–15 points – balance is disturbed, 15–25 points – balance is average, 25–32 points – balance is good.

The *Dynamic Gait Index* helps to assess patients' ability to perform tasks while walking, as well as changing the performance environment, the main assessment aspect is the risk of falling. The specialty of this index is the assessment of the quality of walking and balance of elderly patients, as well as patients who have experienced stroke. The assessment consists of dealing with tasks during walking and stepping up. The test consists of 8 tasks, each of them is scored from 0 to 3 points. Score value: 0 points – cannot perform the task; 1 point – ability to perform tasks inaccurately; 2 points – ability to perform tasks with auxiliary means; 3 points – perform the task.

Maximum score is 24. Assessment of test results: 0–19 points – high risk of falling; 20–22 points – average risk of falling; 22–24 points – there is no risk of falling.

Postural Scale for Stroke is one of the most popular scales for assessing the balance of stroke patients, regardless of torsion control abilities. This test is based on three main objectives: assessing the patient's ability to remain in a stable position, assessing balance in situations of change, and assessing skills when tasks are gradually getting harder. The test consists of two parts (tasks without changing the position and tasks by changing the position). A total of 12 different tasks, each of them is rated from 0 to 3 points. Score value: 0 points – totally unbalanced, torso control impaired; 1 point – the aid used to maintain balance; 2 points – the aid is not used, balance is maintained for a short time; 3 points – perfectly maintains balance.

The maximum score is 36. Evaluation of the test results: 0–15 points – balance and torso control are disturbed, 15–21 points – holds the static balance, but the movement needs help, 21–36 points – the balance and torso control are not distorted.

Mathematical Statistics. Statistical data analysis was performed using *Microsoft ® Excel 2010* and *SPSS 23.0 programs*. The sample sizes were compared with Wilcoxon and Mann–Whitney tests. Statistically significant differences were recorded at $p < .05$.

RESULTS

When evaluating both groups balance at the beginning of the study, results in both groups were almost equal, which shows that balance was disturbed and there was a huge risk of fall, moreover all patients walked using aids. At the beginning of rehabilitation, the average score of all balance evaluating tests in both groups was 16.92 and 15.05. In the course of the study, all results were statistically significant ($p < .05$).

At the end of research, variation between all test results was defined as statistically significant. Repeatedly evaluating both groups at the end of rehabilitation, average results of both groups in all tests were improved: in the intervention group, the average at the beginning was 16.92 and after rehabilitation it was 34.79. The average of the control group results in all tests was 15.05 and at the end it was 31.90. Summing up, all results established show that balance in both groups in the rehabilitation period statistically significantly ($p < .05$) improved.

In the research group, after the physiotherapy Berg test average score was 47.66 ± 3.03 points (Figure 1). In the control group, the average score was 40.67 ± 1.83 points. In both groups there was a statistically significant improvement ($p < .05$).

In the evaluation of the balance changes after physical therapy with MiniBest balance test, the average score of the research group was 28.08 ± 1.98 points. In the control group, the average score was 25.67 ± 2.15 points (Figure 2).

At the end of the study, better scores of the balance test scale of the research group could be explained by the fact that balancing training had greater efficiency with static and dynamic balance training using unstable planes.

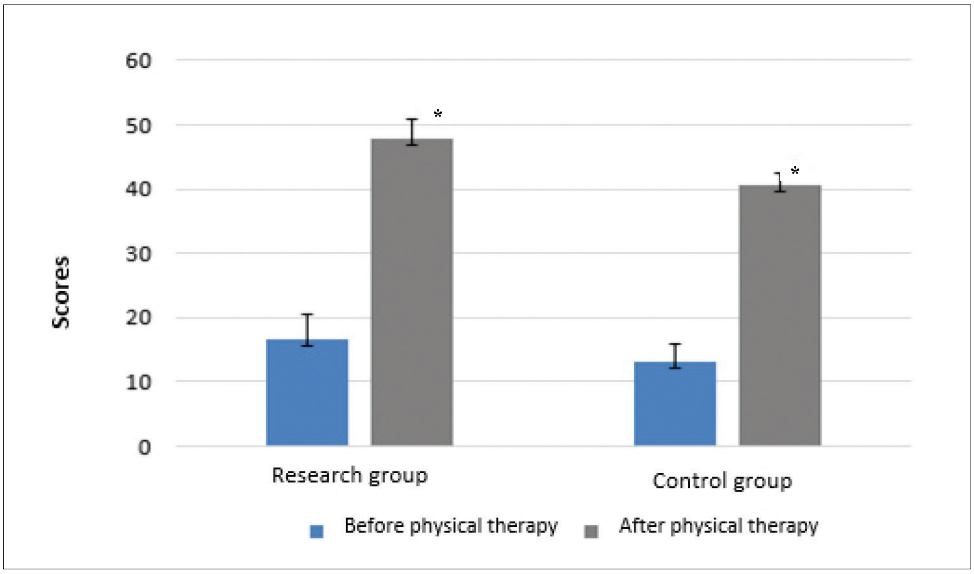
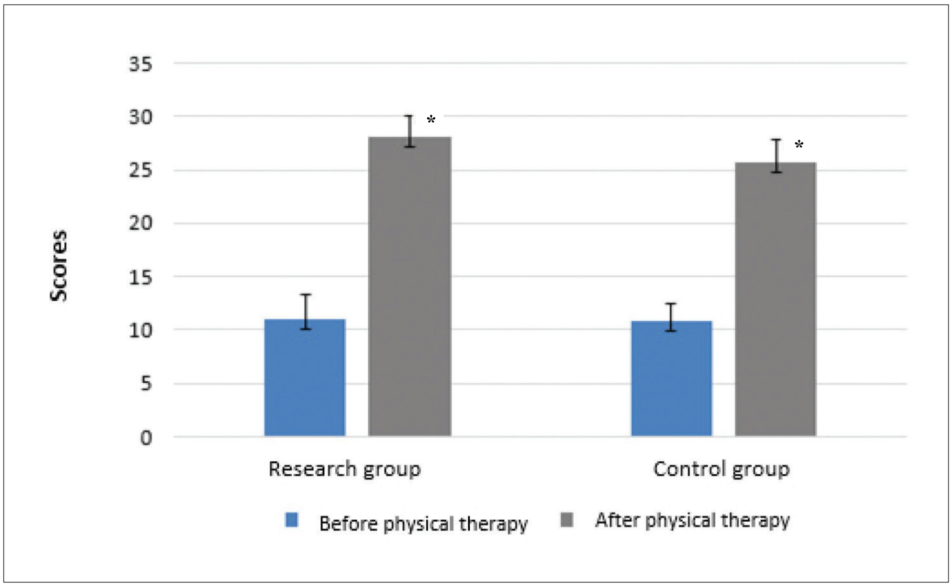


Figure 1. **Berg Balance Scale value in Group 1 and Group 2 before and after physical therapy**

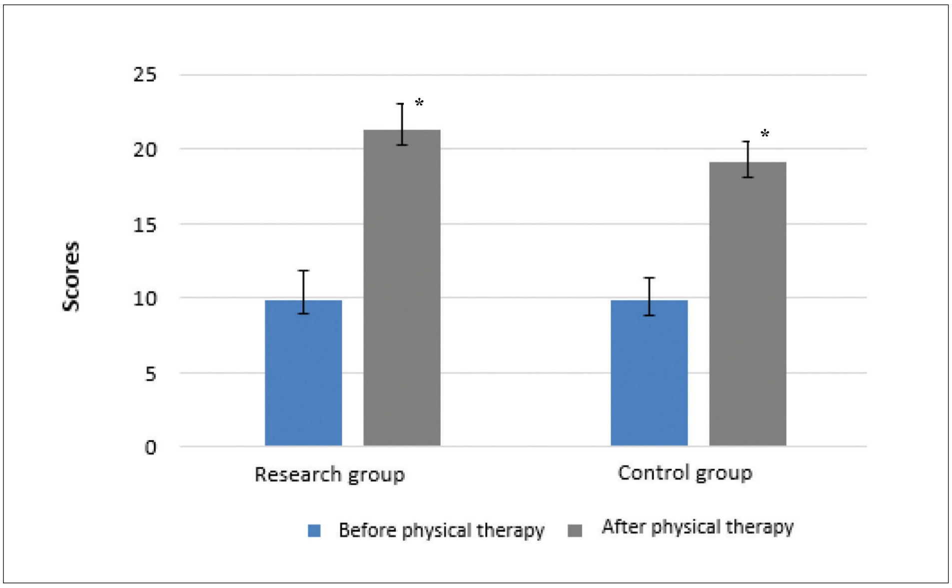
Note. * $p < .002$, comparing the results in different groups before and after physical therapy.

Figure 2. **MiniBest test value in Group I and Group II before and after physical therapy**



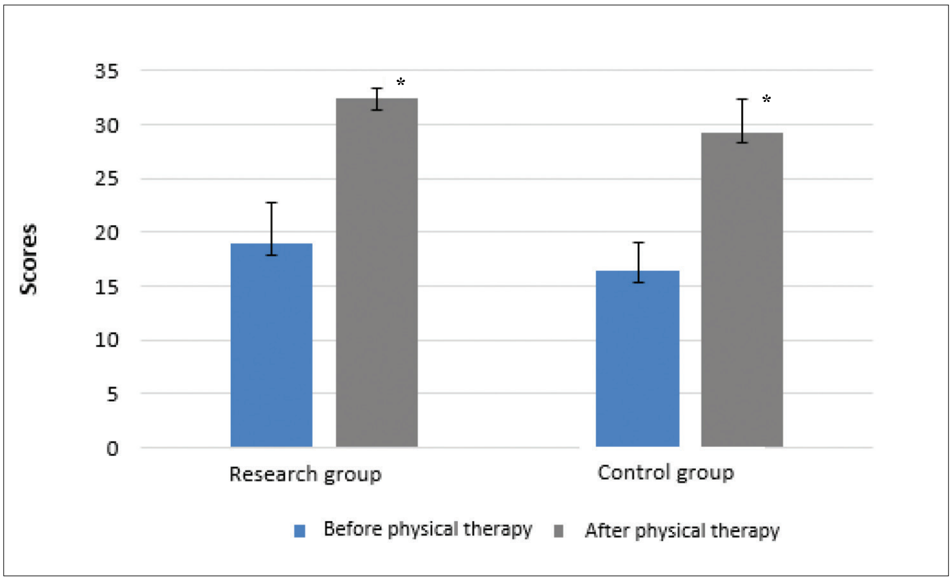
Note. * $p < .002$, comparing the results in different groups before and after physical therapy.

Figure 3. **The Dynamic Gait Index value in Group 1 and Group 2 before and after physical therapy**



Note.*$p < .002$, comparing the results before and after physical therapy in different groups.

Figure 4. **Postural Assessment Scale for Stroke value in Group 1 and Group 2 before and after physical therapy**



Note.* $p < .002$, comparing the results in different groups before and after physical therapy.

As shown in Figure 3, the mean of the Dynamic gait index results of the research and control groups at the end of the study showed a statistically significant improvement ($p < .05$). The average score of the research group was 21.25 ± 1.76 points, and the average score of the control group was 19.17 ± 1.40 points.

In the research group, better scores of the balance test scale of the research group could be explained by the fact that balancing training had greater efficiency with static and dynamic balance training using unstable planes.

In the analysis of the data, the results of the two groups at the beginning of rehabilitation were initially different: the average score of the results of the research group was 18.92 ± 3.75 points; the average score of the control group results was 16.42 ± 2.68 points. At the end of the study, the results of both groups were better than those at the beginning, the change in results was statistically significant ($p < .05$). The average score of the research group was 32.42 ± 0.90 points, the average score of the control group was 29.25 ± 3.05 points (Figure 4).

DISCUSSION

After analysing the data, we can see that after all physical therapy programs we applied, the results of all tests we did were improved, and their change was statistically significant ($p < .05$). Only by comparing the results of the change between the groups, we can conclude that the first physiotherapy program that used the unstable planes to train achieved better results. Meanwhile, the second study group, whose balance was trained by walking, had worse results.

During the procedure, the control group performed exercises involving walking training elements. The results of our study showed that the walking elements had a positive effect on the improvement of balance. A similar study was conducted by Karbauskaitė and co-authors (2017). The authors tracked changes in their study using a specialized walk-through program. During the study, the research group received a complex physical therapy program along with a specialized walk-through program, and the control group received a complex physical therapy program. In this study, a Berg balance scale and a dynamic gate index were used. The results obtained in both groups showed statistical significance ($p < .05$), but the results of the research group had a higher statistically significant difference compared to the control group. The tests used in the study were chosen the same as we did. Analysing the results of the test, results at the end of the study were different from the results obtained by us. The average Berg balance scale was 51.82 ± 3.6 points, and our average score was 40.66 ± 1.83 points. The results of the dynamic gate index in the study were 21.27 ± 2.8 points, and the average score we obtained was 19.17 ± 1.40 points.

Kong and co-authors (2015) conducted a study to analyse the effects of different planes on the balance of patients with a history of stroke. During the study, the subjects were randomly divided into four groups, in which different surfaces were used for balance improvement. The tests that the authors chose were not the same as ours. The results of the study showed that changes in the results of all groups were statistically significant, but the third group, which used with physical therapy program with different unstable planes, had the highest statistical significance in assessing changes in balance than in the other three groups.

Yoo, along with co-authors (2014), conducted a study that assessed balance training using unstable platforms and core stabilization exercises. The Berg balance scale was used to assess the effectiveness of the study. The results of the study indicate that exercises using unstable planes have statistically significant results and are recommended as a good method for developing balance in patients with a history of stroke. The results obtained were similar to the results of our study – the average score for the assessed results among the groups was 5.69 points, and in our study it was 4.95 points.

Park, along with co-authors (2015), conducted a study in which balance was trained through walking tasks. The tests used in the study were not the same as we selected, but the results of the study indicate that balance improves because of walking training.

Bang and co-authors (2016) conducted a study in which balance was improving with walking exercises. Statistically significant differences were observed in the balance between the two groups (for the first group balancing exercise was walking tasks and the virtual game – Nintendo; the second group was subjected to a program based on special walking exercises and walking on the running track). When comparing changes in the groups, statistically significant changes were in the first group, which sustained from balance training exercises and virtual play.

Our research hypothesis was proven: the results of all tests used in the study between groups were statistically significant ($p < .05$), so we can say that in patients who suffered from a stroke during rehabilitation, using a physical therapy program that involves exercises with unstable planes is more effective in balance training than a physical therapy program, including walking training elements. In addition, both physiotherapy programs had a positive effect on balance.

CONCLUSIONS

1. During physical therapy, the dynamic and static balance of both groups were statistically significantly improved.
2. Comparing the results between the groups, a statistically significant change was seen in the research group, the balance improving program of which consisted of a physical therapy program using unstable planes.
3. In both groups, subjects at the beginning of rehabilitation started walking with aids, and the results of the evaluated tests indicated that balance was disturbed, and at the end of the rehabilitation the subjects walked without the aids.
4. Balance training using unstable planes greatly improves the balance of patients with a history of stroke.

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EFFECT OF STRENGTH AND ENDURANCE TRAINING PROGRAM ON MENTAL AND PHYSICAL HEALTH OF SPINAL CORD-INJURED PERSONS

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ABSTRACT

Background. The aim of the research was to examine the effects of eight weeks of strength and endurance training on the improvement of mental health and physical state of spinal cord-injured persons.

Methods. Twelve persons with spinal cord injury (SCI) participated in an eight-week intervention program of mainly two training types: strength and wheelchair driving endurance training. Subjects with SCI represented the experimental and control groups. The mental (Ware, 2000) and physical (isometric strength of the hand grip, strength of the shoulders and arms bench press, aerobic endurance 12 min and anaerobic endurance 30 s driving the wheelchair tests) values were evaluated before and after the program.

Results. After the primary questioning of the experimental group participants before organizing strength and endurance training program and the final questioning after the program, it was revealed that most values of mental health improved. The physical state characteristics of persons with spinal cord injury revealed differences between pre-test and post-test values.

Conclusions. This study indicated that persons with spinal cord injury involved in eight weeks strength and endurance training program improved mental and physical health parameters in comparison with persons with spinal cord injury not participating in any training program. Isometric force and 12 min wheelchair driving are good markers for strength, power and endurance in persons with spinal cord injury.

Keywords: strength and endurance training, psychical and physical health, spinal cord-injured persons.

INTRODUCTION

As a result of a spinal cord injury, the somatic and autonomic nervous system is damaged. The most serious consequence is paralysis of muscles below the level of the lesion, depending in severity on the completeness and level of lesion. Secondary complications may occur as a consequence of spinal cord injury, such as urinary tract infections, spasticity, hypotension, autonomic dysreflexia, pressure sores, arm overuse injuries, fractures, venous thrombosis and respiratory infections (Giacobbi, Stancil, Hardin, & Bryant, 2009). Moreover, having lost a considerable part of the functioning of their (lower) body, often leading to a wheelchair-dependent life, it is difficult for those with spinal cord injury to maintain an active lifestyle. As a consequence of the spinal cord injury, the secondary complications and the sedentary lifestyle of people with spinal cord injury, deconditioning is likely to occur with increased risk of obesity, diabetes and cardiovascular diseases (Martin, Jetha, Mack, & Hetz, 2010; Valent, Dallmeijer, Houdijk, Talsma, E., & van der Woude, 2007). Deconditioning in turn results in a lower physical capacity. Therefore people with such injuries will have difficulty in coping with the strain of daily activities (Hicks et al., 2011; Valent et al., 2007). They become less physically active, passive, have no motivation to achieve something, often leading to depression, bad mood, feeling helpless (Martin et al., 2010; Kennedy et al., 2010).

Physically disabled persons often experience physical, emotional, psychological stress because they became dependent, passive, without trying to participate in everyday life actively (Columna, 2009; Tasiemski & Brewer, 2011). People with spinal cord injury who are not able to participate in daily activities appear to be more handicapped (e.g. in the domains of physical independence and mobility) and tend to give lower ratings for quality of life (Tavakoli et al., 2016). To cope adequately with the strain of daily activities and to prevent long-term secondary health problems, it is important to have and maintain an optimum level of physical fitness. Physical fitness is often developed during initial rehabilitation and must be maintained in the process of a long-term physically active lifestyle and/or rehabilitation after care. This requires an understanding and the availability of evidence-based training methods and exercise protocols for people with spinal cord injury. Although guidelines for upper body training in people with spinal cord injury have been published by several authors, the experimental evidence base of these guidelines is unclear (Sisto & Evans, 2014). That is why in scientific literature, new means and ways how to improve mental and physical health of spinal cord-injured persons are being searched (Hicks et al., 2011; Giacobbi et al., 2009). Most training programs for persons after spinal cord injuries are long-term and last from 12 to 16 weeks (Hicks et al., 2011; Lovell, Shields, Beck, Cuneo, & McLellan, 2012). However, the impact of shorter-term moderate intensity combined strength and endurance training on wheelchair users remains unclear. The question about endurance progress of wheelchair users in a short period of time has to be answered. The information is useful for professionals working in the fields of rehabilitation, recreation and physical activity enhancement with persons after spinal cord injury because it shows the possibilities to achieve maximum results of mental and physical health in the indicators vital for this population. Such information can also be useful in planning training, allowing achieving best strength and cardio-respiratory system results, improvement of psychical health in a shorter period of time and further development of special skills important for a specific sport.

The aim of the research was to examine the effects of eight weeks of strength and endurance training for the improvement of mental health and physical state of spinal cord-injured persons.

METHODS

Subjects. Twelve spinal cord-injured persons with paraplegia after complete spinal cord injury in thoracic and lumbar lesion participated in the investigation. Subjects with SCI represented the experimental and control groups. The age of the subjects ranged from 19 to 32 years, the history of spinal cord injury was from 3 to 18 years. Their physical characteristics were 175 (7.2) cm height and 71.2 (4.6) kg weight. All the subjects had an acquired disability.

The experimental procedures were approved by the Kaunas Region Biomedical Research Ethics Committee.

The experiment. To address the primary hypothesis of this investigation that spinal cord-injured persons profit from strength and endurance training, all the subjects were assigned to the 8-week resistance and endurance training regimen.

The following variables were assigned as dependent variables: isometric strength of the hand grip, strength of the shoulders and arms (bench press), 12 min. aerobic endurance, and 30 s anaerobic endurance while driving the wheelchair were measured, and then mental health values were evaluated. Assessments were performed before and after the training period.

The participants of the control group did not participate in experimental program.

The participants of the experimental group had four training sessions per week, two hours per training session in the gym (two times per week strength training) and endurance training (two times per week).

Endurance training sessions were subject to moderate-intensity physical activity HR peak 60%, the maximum pulse 167 bt · min^{-1}, and the average pulse 146 bt · min^{-1}. Wheelchair rides were performed 4 times for 30 minutes each with 5 minutes recovery phase.

Exercises for improving strength were applied with circuit training sessions in the gym using facilities and equipment adapted for wheelchair users spinal cord-injured persons. Each session was divided into the warm-up part, the main part and the cool-down part. During the warm-up, athletes with disability stretched their shoulder muscles for 10 min. During the main part of the session, the subjects completed 3 sets of 8–12 repetitions of 8 different strength exercises designed for the shoulder muscles. Two hours strength training sessions were subject to moderate-intensity physical activity HR peak 65%, the maximum pulse 172 bt · min^{-1}, and the average pulse 149 bt · min^{-1}.

For determining values of psychical health questions of evaluating psychical health statements from SF-36 questionnaire (Ware, 2000) were used. Vitality, energy, emotional state of spinal cord-injured persons were evaluated from 1 (the worst rate) to 6 (the best rate) points.

For evaluating isometric strength hand grip the subject was asked to squeeze the dynamometer ((Jamar, USA) with maximum isometric effort, which was maintained for about 5 seconds. Best of three attempts with 30 s rest between them was recorded.

For evaluating maximal strength of the shoulders and arms, each subject was asked to complete lifting the maximal weight (one repetition) lying in the bench trials (preliminary, after 8 weeks).

Evaluating aerobic endurance 12 min wheelchair driving, subjects lined up on the baseline (basketball court, length 28 m) on a start sign started sprinting to far baseline and back. The total distances per 12 min to complete the test were recorded.

Evaluating anaerobic endurance 30 s wheelchair driving, subjects lined up on the baseline (basketball court, length 28 m) and on a start sign started sprinting to far baseline and back. The total distances per 30 s to complete the test were recorded.

Statistical Analyses. The results were processed using SPSS. All the results are reported as mean and standard deviations. A paired *t*-test was used to compare pre- and post-test values for the control and experimental groups to determine statistical significance. The significance level was set at $p < .05$.

RESULTS

After the primary questioning of the experimental group participants before organizing strength and endurance training program and the final questioning after the program, it was revealed that most values of mental health improved (Table 1). Strength and endurance exercises stimulated positive emotions and increased energy, vitality, fullness of life, feelings of quietness, peacefulness and happiness of physically disabled persons. After the strength and endurance training program, physically disabled less experienced negative

Table 1. **Values of mental health of experimental group of spinal cord-injured persons before and after the program**

Mental and emotional well-being	Mean values of SCI persons before the program (points)	Mean values of SCI persons after the program (points)
Sensational fullness of life	4.5 ± 0.25	5.7* ± 0.05
Nervousness	3.9 ± 0.21	5.3* ± 0.03
Bad mood feeling	4.3 ± 0.68	5.6* ± 0.12
Feeling of quietness and peacefulness	4.5 ± 0.16	5.9* ± 0.24
Energy	4.8 ± 0.26	6.0* ± 0.12
Sadness and gloominess	5.5 ± 0.31	5.7 ± 0.06
Depletion feeling	4.9 ± 0.19	5.4 ± 0.45
Feeling of happiness	4.7 ± 0.02	5.7* ± 0.13
Tiredness	4.5 ± 0.3	5.8* ± 0.15

Note. * – statistically significant difference ($p < .05$) between values of mental health of participants before and after the program.

Table 2. **Values of physical state in control group spinal cord-injured persons before and after the program**

Physical tests	Mean values of SCI persons before the program	Mean values of SCI persons after the program
Isometric strength of the hand grip (kg)	50.4 ± 0.24	58.6* ± 0.23
Strength of the shoulders and arms (bench press) (kg)	69.2 ± 2.12	78.9* ± 3.34
Endurance 12 min wheel-chair driving (m)	10.3 ± 2.02	151.2* ± 3.87
Anaerobic endurance 30 s wheelchair driving (m)	68.9 ± 0.22	79.8* ± 0.16

Note. * – statistically significant difference ($p < .05$) between values of physical state of participants in the experimental group before and after the program.

feelings: less nervousness, they rarely had bad mood, sadness and gloominess, they were less stressed and tired. The values of mental health of the control group did not change after the experiment.

The physical state characteristics of persons with spinal cord injury revealed differences between pre-test and post-test values (Table 2).

The physical state values of the control group did not change after the experiment.

DISCUSSION

The major finding of the current study was that eight weeks of strength and endurance training significantly improved mental and physical health of spinal cord-injured persons. The data of the study suggest that improvement of mental health and physical state is closely dependent on the type of training and on the period of training. Eight-week moderate intensity strength and endurance training exercises have more potential to improve mental and physical health parameters in comparison with a longer term (12 and 16 weeks) training as it was documented in the current study. This type of training seems to have an advantage in constructing training plans for persons with spinal cord injury to gain a high level of strength and endurance basis, and then it could be continued with a high intensity exercise training period specified by sport competition conditions.

Because of disability and restrictions of movement in non-accessible environment, physically disabled persons often experience disorders of psychical health. They become nervous, tense, experiencing feelings of frustration with life and the current situation. According to the data of the study, strength and endurance exercises have a positive effect on values of psychical health in spinal cord-injured persons. After strength and endurance training, participants felt energy, vitality, experienced fullness of life, feelings of quietness, peacefulness and happiness. The data of the study reveal the fact that exercises performed in the gym and in the stadium had a positive effect on mood in physically disabled persons helping to relax their nervous system, preventing depression and negative feelings, senses of depletion and tiredness that often accompanied severe disabilities (Kennedy et al., 2010).

Strength and endurance training is important for persons with spinal cord injury, as it was documented in this study. These findings are important because some authors and coaches speculated about minor adaptation capacities to training exercises in subjects with spinal cord injury in general. Evaluation of aerobic performance can be used to analyse the functioning of cardiovascular, respiratory and neuromuscular systems, providing a global assessment of the integrative physiological responses and probable relationship with functional capability (De Groot et al., 2012). Nevertheless, it is difficult to compare the results of different studies that have measured aerobic performance because they differ in a number of factors, including type of tests (MSFT, Cooper, Leger), or the variables measured (VO_2max, distance, HR, lactate). In this study, persons with spinal cord injury showed a significant (p < .01) difference between pre- and post-test a mean distance covered of 1512* ± 387 m. In any case, the mean distance covered values in our subjects are lower than those reported in the literature for international wheelchair basketball players (De Groot et al., 2012; Yanci et al., 2015).

Isometric strength (IS) value was improved in the post training period by 16%. Previous studies showed a big range in strength values between pre- and post-test, ranging from 12% to 30% (Valent et al., 2007). The current study showed similar results of strength values in comparison with the mean value given in literature (Valent et al., 2007). It documents, the eight week moderate-intensity strength and endurance training had an impact on IS value for spinal cord injured persons. The improvement of IS could be considered to be small in comparison with studies of some authors (de Groot et al., 2003). De Groot et al. (2003) demonstrated a 46% of improvement after 16 weeks of intensive endurance and strength training. However, it is difficult to compare these data because of the different content of the program applied in this study and very low initial data of the participants. It seems that the moderate-intensity strength and endurance eight-week training positively influenced the improvement of strength of the upper body, the trunk stability and muscular coordination in spinal-cord injured persons.

CONCLUSIONS

In conclusion, this study indicated that persons with spinal cord injury involved in eight weeks strength and endurance training program improved mental and physical health parameters in comparison with persons with spinal cord injury not participating in any training program. Isometric force and 12 min wheelchair driving are good markers for strength, power and endurance in persons with spinal cord injury.

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Acknowledgements. On the Acknowledgement Page the authors are required to state all funding sources, and the names of companies, manufacturers, or outside organizations providing technical or equipment support (in case such support had been provided).

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