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WHAT DO WE KNOW ABOUT WHOLE BODY VIBRATION?

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SUMMARY

Introduction
The last decade has been characterized by extremely dynamic development in the field of research and subsequent practical applications of new physiotherapeutic techniques. Whole Body Vibration is a relatively new kinesitherapeutic method that improves muscle activity and, as a result, the patient's functionality. The effectiveness of this method is still the subject of research.

Aim
The aim of this paper was to review the literature and present a current and evidence based knowledge of Whole Body Vibration.

Material and methods
Medline and Pubmed databases were used for the search of relevant scientific papers results. Keywords in following order were entered: whole body vibration, muscles activity, EMG, strength muscle, body balance, functionality. Only researches from 2012 to 2017 were taken under consideration. Finally 30 papers have been identified and describe in this paper.

Results
Whole Body Vibration has been widely used in clinical and sport practice. The analysis of the presented articles can indicate a positive impact of whole body vibration on muscle strength and body balance.

CO WIEMY NA TEMAT TRENINGU WIBRACYJNEGO CAŁEGO CIAŁA?

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STRESZCZENIE

Wstęp
Ostatnia dekada charakteryzowała się niezwykle dynamicznym rozwojem w dziedzinie badań i praktycznych zastosowań nowych technik fizjoterapeutycznych. Wibracja całego ciała jest stosunkowo nową metodą kinezyterapeutyczną, która poprawia aktywność mięśni, a w rezultacie funkcjonalność pacjenta. Skuteczność tej metody jest nadal przedmiotem badań.

Cel
Celem tego artykułu było dokonanie przeglądu literatury i przedstawienie aktualnej i opartej na dowodach wiedzy na temat metody leczniczej wibracji całego ciała.

Materiał i metody
Do niniejszego artykułu wykorzystano doniesienia zamieszczone w bazach MEDLINE i Pubmed. Wprowadzono następujące słowa kluczowe: wibracja całego ciała, aktywność mięśni, elektromiografia, siła mięśniowa, równowaga ciała, funkcjonalność. Uwzględniono jedynie badania z lat 2012–2017. Wszystkie znalezione prace spełniające kryteria wyszukiwania w liczbie 30 zostały omówione w niniejszej pracy.

Wyniki
Wibracja całego ciała była szeroko stosowana w praktyce klinicznej i w sporcie. Analiza przedstawionych artykułów może świadczyć o pozytywnym wpływie wibracji całego ciała na siłę mięśni i utrzymanie równowagi ciała.

Conclusions
Based on the available literature, it can be concluded that Whole Body Vibration can improve muscle's activity, strength, endurance and balance control.

Keywords: whole body vibration, muscles activity, EMG, strength muscle, body balance, functionality

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Wnioski
Na podstawie analizy dostępnej literatury sugeruje się, że wibracja całego ciała może poprawić aktywność mięśni, siłę, wytrzymałość oraz równowagę.

Słowa kluczowe: wibracja całego ciała, aktywność mięśni, elektromiografia, siła mięśniowa, równowaga ciała, funkcjonalność

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Introduction

Whole Body Vibration (WBV) is a relatively new kinesitherapeutic method that improves muscle activity and, as a result, the patient's functionality. The effectiveness of this method is still the subject of research (Lienhard *et al.*, 2017; Borges *et al.*, 2016). One of the WBV elements evaluated in available publications (Friesenbichler *et al.* 2014) is a way transmission of mechanical stimuli caused by vibration to individual muscles, and as a result, the results of this transmission to issues related to muscle activity, possible change of their strength, endurance or power, finally affecting postural reactions. It is worth noting here that an important factor quantifying the WBV's effectiveness is its methodological determinants (Tsukahara *et al.*, 2016). For example, Ritzmann *et al.* (2013) and Perchthaler *et al.* (2013) have shown that the increase in muscle activity depends on the type of vibration, its frequency, the position of the practicing body during vibration and additional loads during this type of exercise. Similar observations were made by Lienhard *et al.* (2014). Other authors also came to similar conclusions based on the conducted research (Cidem *et al.*, 2017). Tankisheva together with co-workers (2013) proved that there is a relationship between the posture of the person subjected to vibration and the change in the activity of its muscles. In general, the degree of muscle activation after vibration of the whole body is a derivative of, among others, the individualization of vibration parameters, which is confirmed by the EMG results (Carlucci *et al.*, 2016). The question then arises whether the vibration of the whole body has a local or global range in relation to the activation of individual muscle groups and whether the level of "initial" training affects the value of muscle activity increase as a vibration effect (Lienhard *et al.*, 2015; MacIntyre and Cort 2014, Ashnagar *et al.*, 2016). The effectiveness of WBV was also evaluated through the prism obtained by its use of the increase in strength or muscle power (Yu CH *et al.*, 2015; Stania *et al.*, 2017; Costantino *et al.*, 2017; Dallas *et al.*, 2015; Cheung *et al.*, 2016; Rogan *et al.*, 2015; Hawkey *et al.*, 2016). Another issue assessed was the comparison of the effectiveness of classic methods of muscle activation, i.e. exercise and vibration of the whole body (Fisher *et al.*, 2014). It was also analyzed whether WBV increases the effects of classic methods of muscle activation if it is used simultaneously with them (Marín *et al.*, 2015; Jones *et al.*, 2017; Fisher *et al.*, 2015). Last years were a period of research assessing the impact of vibration of the whole body on the patient's body balance (Ochi *et al.*, 2015; Sonza *et al.*, 2015; Sitjà-Rabert *et al.*; 2015, Yang *et al.*, 2017; di Cagno *et al.*, 2017).

Aim

The aim of this paper is to review the literature and present a current and evidence based knowledge of Whole Body Vibration.

Materials and methods

A systematic review of the literature found in PubMed and Medline database was conducted. Keywords in following order were entered: whole body vibration, muscles activity, EMG (electromyography), strength muscle, body balance, functionality. Only researchers from 2012 to 2017 were taken under consideration.

Results

Finally 30 papers have been identified and describe in this paper. Twenty publications were chosen and presented in Table 1.

Discussion

The last decade has been characterized by extremely dynamic development in the field of research and subsequent practical applications of new physiotherapeutic techniques. A significant place among them is taken by WBV. It uses the effects of vibration which the patient's body is subjected to improve muscle activity, strength, endurance and power, which in turn translates into its greater physical fitness, more precise postural reactions and, finally, a higher level of functionality. For the understanding of the effect of vibrations on the body in general terms, it seems that the results of studies by Friesenbichler *et al.* (2014) are crucial because they are indicating that the effect of vibration depends on the type of muscle and the frequency of vibrations, although these tests were performed on animals.

As with any new method used to treat a patient, the question arises whether it is possible to apply to every patient, and if so whether there are any factors determining its usefulness in specific clinical cases. Lienhard *et al.* (2015) showed a significant increase in muscle activity as a result of vertical vibration. It is worth noting, however, that the authors assessed the activity of lower limb muscles. Further, almost the same authors (Lienhard *et al.* 2017), using the age criterion, showed that an important positive effect of vertical WBV has higher effectiveness in elderly people comparatively to young people. Mentioned authors, by the use of surface EMG, showed greater muscle activity tibialis anterior, gastrocnemius medialis, soleus, vastus lateralis, vastus medialis, and biceps femoris in older people. Similarly, Hawkey *et al.* (2016) showed that vibratory training improves the motor skills of people in middle age. Important insights on the impact of vibration on the increase in lower limb muscle activity were those made by Lienhard *et al.* (2015). According to these authors, the level of muscle activation is not affected by the previous physical activity of the subjects.

Although WBV is a very popular method of rehabilitation used both in sport and in rehabilitation, not all studies have proven that it gives positive therapeutic effects. Borges *et al.* (2016) have shown that vibration does not positively affect the center of feet pressure (COP) oscillations, the normalized peak of force generated by the muscles after its use (maximal peak torque), the total work that muscles can do after vibrational training (total work), the average muscle power after vibration and ultimately did not observe an increase in muscle activity in EMG studies. Another important issue related Stania *et al.* (2017) showed in their research that a 4-week training on a vibrating platform with a frequency of 60 Hz results in a significant increase in the mean values of peak torque, average peak torque and total work for knee flexors at high angular velocity of movement in knee joint especially with respect to knee flexors. Also Dallas *et al.* (2015) showed that WBV strengthens the muscles of the lower limbs, which can be observed immediately after the end of vibration.

Another interesting problem connected with WBV was the attempt to answer the

Table 1. Literature review on the use of WBV and obtained results.

Measurement	Study	Participants	Methods	Results
muscle activity	Lienhard K *et al.* Int J Sports Med. 2015	30 active and 28 inactive participants	EMG	+
muscle activity	Marín PJ & all J Musculoskelet Neuronal Interact. 2015	28 recreationally active students	EMG	+
muscle activity	Ochi A *et al.* Arch Gerontol Geriatr. 2015	20 women: 2 groups	EMG	+
muscle activation	Tankisheva E *et al.* J Strength Cond Res. 2013	8 healthy subjects	Accelerometer	+
muscle activation	Carlucci F *et al.* J Strength Cond Res. 2016	29 students	EMG	+
lower-limb muscle activity	Lienhard K *et al.* J Biomech. 2017	30 young and 30 older individuals	EMG accelerometer	+
upper -limb muscle activity	Ashnagar Z *et al.* J Back Musculoskelet Rehabil. 2016	40 active females: WBV group and control group	EMG	+
muscle strength	Rogan S *et al.* Eur Rev Aging Phys Act. 2015	65 years or older elderly individuals	a literature search (38 articles)	+
muscle strength	Stania M *et al.* Biol Sport. 2017	49 male subjects: 7 comparative groups	The isokinetic strength tests	+
isometric muscle strength	Fisher J *et al.* J Sports Med Phys Fitness. 2015	24 participants 3 groups: isometric training with and without vibration and control groups	isometric deadlift dynamometer	+/−
muscle power	Hawkey A *et al.* J Strength Cond Res. 2016	25 active women: middle-aged (WBVT and control group) younger (WBVT and control group)	Probotics Just Jump Mat Sit-and-reach box	+
neuromuscular activity	Perchthaler D *et al.* J Sports Sci Med. 2013	51 healthy participants: 5 different vibrations-frequency groups	EMG	depend on the biomechanical variables
muscle strength after ACL reconstruction	Costantino C *et al.* Clin J Sport Med. 2017	38 female volleyball/ basketball players: WBV group and control group	Biodex dynamometer	+
flexibility and explosive strength of lower limbs	Dallas G *et al.* Biol Sport. 2015	18 male and female divers: 3 protocols	the S&R test (a flex-tester box) Jump tests (a switch mat)	+
muscle strength imbalance in lower limb	Yu CH *et al.* Biomed Mater Eng. 2015	20 women: WBV group and control group	BIODEX System 3	+
balance and muscle strength	Cheung WH *et al.* J Musculoskelet Neuronal Interact. 2016	59 elderly women: WBV and control group	dynamometer the Basic Balance Master System	+
balance and muscle strength	Yang F *et al.* J Biomech. 2017	23 young adults with obesity: vibration and placebo group	isometric strength dynamic stability	+
neuromuscular performance and postural control	Borges DT *et al.* Man Ther. 2016	60 physically active women: control group, 30 Hz and 50Hz groups	EMG isokinetic performance baropodometry	−
balance and muscle performance	Sitjà-Rabert M *et al.* J Am Med Dir Assoc. 2015	159 participants: WBV plus exercise group and exercise group	Tinetti test TUG STS test SmartCoach encoder	−
balance	di Cagno A *et al.* Disabil Rehabil. 2017	24 participants: blind males and non-disabled males	balance platform	−

question whether it affects only selected muscle groups or has a global range. This is important because in most of the research results presented here, the patient stood on the vibrations platform with slightly flexed lower limbs at knee joints. Tsukahara *et al.* (2016) showed in their work on young, healthy volunteers that the support of the elbows on the knees during vibration results in the transfer of vibrations to the upper limbs and the activation of their muscles and not only the muscles of the lower limbs. The vibration effect expressed by the increase in muscle activity is a derivative of the vibration frequency parameter and a specific body position during its lifetime that generates additional load on vibrated muscles. Also Ashnagar *et al.* (2016) observed that vibratory training with the simultaneous performance of specific exercises activating the muscles of the shoulder girdle and upper limbs (modified push-up position) leads to their significant activation in the EMG assessment. This observation concerned muscles: upper trapezius, serratus anterior, biceps brachii and brachii brachii. Ritzmann *et al.* (2013) proved that during the vibration, the posture with the plantarflexion of feet (position of standing on fingers) and knees flexed to 60°, results in greater activation of the knee flexor muscles than in other positions, and what is more the activation level in this position is straightforward proportional to the vibration frequency used. According to Tankishev *et al.* (2013) the influence of knee flexion angle on the degree of activation of the muscles of the iliac girdle and lower limbs is not clearly defined. Also the relation between muscle activity vs. the frequency and amplitude of vibrations is not unambiguous.

The contrary opinion was expressed on the basis of the research carried out by Fisher *et al.* (2015). These authors put forward the thesis that the influence of knee flexion angle and frequency of vibrations on the increase in the activity of lower limb muscles is not unequivocally resolved and what is more, vibration does not significantly strengthen the lower limb muscles compared to isometric exercises. Carlucci *et al.* (2016) pointed out in their research to the need to individualize the parameters of the vibration and body posture of the person subjected to it. Also these authors showed the dependence of the increase in muscle activity of the lower limbs from the angle of the knees flexion and the frequency of vibrations. Also Cidem *et al.* (2017) highlighted the importance of the body position during vibrations and the resulting dynamic interactions between the body and the ground, affecting the degree of muscle activation during vibration. What's more, they proved that the vibration effect is all the higher the higher the vibration frequency was applied.

The significance of the vibration frequency and its amplitude for the obtained activation of the lower limb muscles was also pointed out by Perchthaler *et al.* (2013) proving in research on middle-aged people that better results are obtained at higher frequencies and amplitudes. Interestingly, the aforementioned authors have proved that vibration training activates the knee extensors to a greater extent than the flexors depending on the angle of flexion.

In the assessment of the impact of vibration on the electromyographically recorded increase in muscle activity, the decisive role is played, in opinion of Lienhard *et al.* (2015), by way of registration. EMG is a very sensitive diagnostic method that reacts to the vibration of the occurrence of artifacts in the record which may significantly influence the assessment of the results in terms of the expected therapeutic effect. These researchers have recommended the use of spectral linear interpolation or a multiple harmonics in the registration of sEMG performed during vibrations if such methodical assumptions were accepted in the test protocol.

Interesting observations were made by Sonza *et al.* (2015), investigating the effects of different frequency vibrations on sensitivity for the touch on the lower limbs, surface temperature and the quality of the body balance. According to these authors, the vibration, especially the one with the higher frequency, reduces the sense of touch, the decrease in the surface temperature of the lower limbs probably caused by vasoconstriction and deterioration of the body balance in the tests performed 10 minutes after the end of vibration.

According to Jones *et al.* (2017) the vibration effect in relation to the muscle power of the upper body is the largest after 10 minutes from its completion. Researchers have found that the power value obtained is influenced by the body position during vibration with the additional upper body load (plyometric push-up). Similarly, Marin *et al.* (2015) proved in their research on young, healthy volunteers that the level of muscle activity increase of the person subjected to vibrations is decisively influenced by their additional load. Such a load is most often the exercises performed during vibrations and directed to specific muscles whose activation we are interested in. The authors proved that the use of battling rope exercises during vibration significantly activates the muscles: gastrocnemius medialis, vastus medialis oblique, vastus lateralis, rectus abdominis, multifidus, brachii biceps, and brachii triceps.

The need to include additional exercises during vertical WBV for maximum muscle activation was also noticed by Lienhard *et al.* (2014). Research on the effects of vibration on muscle activity does not always indicate its positive effect. For example, MacIntyre *et al.* (2014) showed that vibration does not significantly activate the muscles of the back and what is more, it negatively influences postural reactions.

A separate issue assessed in the research on vibration was the answer to the question whether WBV can lead to symmetry of activities corresponding topographically single-man muscle groups. Performed by Yu *et al.* (2015) studies have shown that WBV leads to symmetry of the activity of the lower limb muscles in cases when there are differences at the beginning. This observation may have significant clinical significance in a number of dysfunctions occurring in rehabilitation practice.

A very interesting field of research on the usability of WBV recently, are projects assessing the impact of this methodology of improvement on postural stability. Yang and co-workers (2017) proved that vibration training significantly strengthens the muscles and improves dynamic stability in obese people. The authors suggested that this is due to improved control of the segmental movement of the trunk. Also Cheung *et al.* (2016) proved the positive impact of WBV. They showed that the vibratory training used for a period of one year with high frequency and low amplitude improves muscle balance and strength in the elderly. Sitja-Rabert *et al.* (2015) in their studies did not show positive effects of WBV in the area of improved balance, gait quality, muscle strength and overall functionality in people the elderly. In the assessment of di Cagno *et al.* (2017) vibration of the whole body used in blind people does not affect qualitatively and quantitatively postural reactions in the assessment performed on the balance platform immediately after the end of the training, which recommends it as a safe method improvement.

Generally, the increase in the activity of lower limb muscles has a functional dimension that can be used in clinical practice. For example, Ochi *et al.* (2015) found that vibration increases the speed of walking by increasing the activity of the flexor of the foot. It also causes an increase in muscle activity of the extensor and knee flexors. The results of the study by Constantino *et al.* (2017) are very important from clinical point of view. Authors have proved that the addition of WBV to the standard rehabilitation program used in patients after ACL reconstruction may significantly increase strength of lower extremities muscles. Last one, a comprehensive assessment of WBV's effectiveness was made based on a meta-analysis of the available literature by Rogan *et al.* (2015). By evaluating the resources of PubMed, Cochrane Central Register of Controlled Trials, Physiotherapy Evidence Database and CINAHL electronic databases and the International Clinical Trials Registry from the World Health Organization and without eliminating any methodological vibrations in the evaluation of its application mode, amplitude and frequency of vibrations showed that it has a positive impact on the elderly, regardless of their level of functionality, which is particularly important for people having problems with performing the simplest exercises.

Conclusions

Based on the available literature, it can be concluded that Whole Body Vibration can improve muscle activity, strength, endurance and balance in different populations.

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