

## Exercise and Health – A review of German speaking publications in the years 2016 and 2017

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This review comprises German monographs and anthologies as well as articles published in professional journals in 2016/2017. This article ties in with the reviews on ‘Physical Activity, Sport and Health’ published in the ‘International Journal of Physical Education’ between the years 2000 and 2016. (Knoll, issue 2/2000, issue 2/2002, issue 2/2004, issue 2/2006, issue 2/2008, issue 3/2010; Knoll & Fessler, issue 2/2012; Knoll, Fessler & Müller, issue 2/2016). The following professional journals were examined systematically: ‘Sportwissenschaft’ (from 2017: ‘German Journal of Exercise and Sport Research’<sup>1</sup>, ‘Spectrum der Sportwissenschaften’, ‘Zeitschrift für Sportpsychologie’, ‘Zeitschrift für sportpädagogische Forschung’, ‘Sport und Gesellschaft’, ‘Deutsche Zeitschrift für Sportmedizin’, ‘Bewegungstherapie und Gesundheitssport’, ‘Sportunterricht’, ‘Sportpädagogik’, ‘Motorik’, ‘Praxis der Psychomotorik’ as well as ‘Prävention und Gesundheitsförderung’.

### **1 Introduction: Basics**

Physical activity and health is an interdisciplinary field of study within sports sciences. For many years it has been an established discipline in German speaking research and is discussed within various disciplines. This is expressed in the many sport scientific congresses and conventions that have taken place within this reporting period.

The Health Committee of the German Society of Sport Sciences<sup>2</sup> (dvs), consisting of a cooperation of researchers of various sport scientific disciplines, sets the scientific standards for German speaking sports sciences through annual conventions and represents both continuity and variety in the development of this area of research. Within this reporting period, the annual convention for 2016 was held on the topic of “Physical Activity, Setting and Health” in which questions were discussed regarding the interaction and existing conflict between changing living conditions and mobilities (cf. Wäsche, Sudeck, Kähler, Vogt & Woll, 2017).

In addition, multiple professional conventions have taken place over the years which have been directed particularly towards teachers (including pre-school), fitness instructors and trainers with the goal of effective transfer of scientific understanding of physical activity and health into practical situations; for example, the congress “Childhood in Motion” (cf. congress proceedings by Hunger & Zimmer, 2016).

Various fundamental articles were published within this review period which are particularly relevant to the topic “exercise and health”. Of utmost importance are the National Recommendations for Physical Activity and Physical Activity Promotion, which were published as a resolution of the 2016 German Bundestag (Rütten & Pfeifer, 2016). As a result, scientifically based and systematically edited recommendations for physical activity promotion are available for the first time. In addition, specific subject groups, such as children and youth, adults, seniors as well as people with chronic illness are systematically differentiated, while also taking aspects of various settings into consideration (e.g. school, work). As such, children between the ages 4 and 6 should be physical active for at least 180 minutes/day and children and youth aged 6-18 for at least 90 minutes/day at a moderate to high intensity level, (approximately 12 000 steps/day) (cf. p. 25f.). In general, the following minimum recommendations are: A minimum of 150 minutes of aerobic physical activity at moderate intensity or at least 75 minutes of aerobic physical activity at high intensity per week. In addition, strength training activities are recommended on at least two days/week (cf. p. 32f.). Based on these recommendations, Baldus and Peters (2017) produced practical suggestions while taking specific aspects of each subject

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<sup>1</sup> Articles in this journal on ‘exercise and health’ published in the English language were not considered for this review.

<sup>2</sup> [www.dvs-gesundheit.de](http://www.dvs-gesundheit.de)

group into consideration. In relation to the National Recommendations for Physical Activity, the article by Rütten (2017) is worth mentioning. This article presents a stronger focus towards the area of public health in sports sciences and demonstrates future possibilities in correlation with (1) the concept of physical activity, (2) a health promotion approach and (3) a scientific approach to program design.

The publication by Kaczmarek, Schwarz and Wydra (2016) on the meaning of mobility concept is of fundamental importance. Mobility is not only an important functional building block and central to daily life but is also required for many types of physical activities and necessary for participation in social life. Measures for maintaining and improving mobility are therefore anchored in the therapy process and must be adapted to the goals, content and methods of exercise therapy to make individualized programs possible.

Huber (2016) as well as Baldus and Steinau (2016) focus on occupation related aspects with discussions surrounding qualifications of sport and exercise therapists. The authors call for stricter guidelines for qualitative education for professionals. Huber (2016) also discusses the development of a so-called "Core Curriculum" for physical activity promotion, which is oriented on the German and European Quality Frameworks (DQR/EQR). In this case, the EQR serves as a guideline, allowing national qualifications to be accepted at the European level. It therefore becomes a reference for comparing various national qualification systems. Baldus and Steinau (2016) highlight structure quality and expectations of sport and exercise therapists for both in- and out-patient rehabilitation. The authors reveal a transition in the clients being treated due to demographic development and the associated shift in illnesses needed to be treated and the corresponding professional requirements.

The publications discussed thus far predominantly address topics regarding 'exercise and health'. The following will discuss articles that focus on diagnostics, parameters and characteristics of health related physical activity (chapter 2). Furthermore, the effects on health in general (chapter 3), followed by health related physical activity with children and youth (chapter 4) as well as adults and seniors (chapter 5) will be discussed.

## 2 *Diagnostics, Determinants and Characteristics*

Within this reporting period, a series of publications appeared that, in addition to addressing various characteristics of health related physical activity, also discuss questions regarding diagnostics and determining factors of athletic activity, i.e. influencing factors on an individual as well as at a collective level.

### *Diagnostics and health related physical activity*

Measuring techniques for objective assessment of physical activity - whether it be as simple as a survey or pedometer, or technically more complicated, such as accelerometry - are of particular importance during this reporting period. Lerchen, Köppel and Huber (2016) as well as Huber and Köppel (2017) use a questionnaire to acquire data regarding sedentary behavior of children and youth between the ages of 5 to 20 years. Herrmann, Gerlach and Seelig (2016) could confirm the validity of the test battery MOBAK-1 for assessing basic motor competencies in elementary schools – in this case, grade one – while Herrmann (2016) presents the test battery MOBAK-5 for the fifth grade. Thiel, Gabrys and Vogt (2016) use a portable accelerometer for assessing physical activity. However, in this study, the method of data collection can be criticized by noting that specific preparations, equipment settings and analysis protocols are required with the use of accelerometry due to varying cognitions, compliance, body composition and movement economy of the subjects.

Articles related to diagnostics in rehabilitation were also published within this review period. Rupp, Moon and Wydra (2016) present the practically established and scientifically proven balance test (GGT) for patients with hip arthritis and/or hip endoprosthesis. By implementing 18 exercises, the GGT provides an assessment of both static and dynamic balance ability as well as balance on an unstable surface.

With the use of a test model for the corresponding hormones, Rathgeber (2017) answers the question if self-learnable awareness programs that can be easily integrated into everyday life can be applied as an effective intervention for chronic stress. The study succeeds in proving that, by implementing such programs, catabolic stress effects (cortisol) can be reduced and anabolic antagonists (testosterone & estradiol) can buffer the stress induced catabolic physical weakness. The so-called Sexual Hormone/Cortisol-Quotient (S/C-Q) explains why some people get sick as a result of permanent stress.

### *Determinants of health related physical activity*

In the development of health related physical activity programs, determinants play a fundamentally important role – i.e. the question if and under which conditions an individual will decide to take part in health enhancing physical activity. In other words, although the positive effects of physical activity on health are well-known, many people still are not able to include physical activity and sport as a permanent component of their lifestyle. Hottenrott, Ketelhut and Hottenrott (2017) provide relevant recommendations on developing training programs for main motor requirements for various age groups and include tips for personalized activity coaching. Könecke, Primke and Simon (2016) present overview data regarding drop-out and compliance rates of cardiac patients in rehabilitation exercise groups. By assessing nine selected studies, the authors were able to demonstrate, that the drop-out rate lies between 3.4 % and 50% and the observed compliance varies between 13 % and 42.6 %. However, it can be criticized that the recorded initiation and stability rates only measure to what extent cardiac patients have followed the doctor's prescription for participation in a rehabilitative exercise group and not if they have chosen another type of physical activity.

To increase the accessibility of physical activity programs, a specified consultation can be applied. Gabrys, Jordan, Behrens and Schlaud (2016) give an overview on the prevalence and trends regarding physical activity consultation by doctors in Germany between the years 1997-1999 as well as 2008-2011. Based on the data from 11 907 people between the ages of 18 and 64 over the span of 10 years, the prevalence of a recommendation towards physical activity significantly decreased from 10.1 % to 8.6 %.

### *Characteristics of health related physical activity*

In addition to endurance training, high intensity interval training (HIIT) currently plays an important role as a training form in both health related and rehabilitation activity programs. Ketelhut, Ketelhut, Riedel, Willich, Meyer-Sabellek, Müssig and Ketelhut (2017) present the results of the effects of moderate interval training on heart rate variability (HRV) in elementary school children. The results prove that, due to an increase in vagal activity, a moderate interval workload can already lead to positive effects on autonomic heart function of elementary aged children. Schweitzer, Wehmeier, Jansen, Probst, Grüter, Hähnchen and Hilberg (2016) examine the effects of HIIT Training. The authors verify that high intensity interval training for cardiac patients, for example, does not pose a higher risk and can even lead to improved cardiovascular effects. HIIT Training does not only have positive effects on cardiovascular and respiratory parameters. One study using Cross-Over-Design by Alack, Kürger and Mooren (2016) provides evidence that the mobilization of blood building progenitor cells is also positively influenced; i.e. the cells move more quickly into peripheral tissue, therefore regenerating tissue cells damaged as a result of injury or illness at a faster rate, or, by replenishing specialized tissue cells during growth phases. Weissenfels, Teschler, von Stengel, Kemmler and Bebenek (2016) test the influence of HIIT Training cardiometabolic risk factors and compare the results with electromyostimulation. The results show a comparable effect regarding the net training time. Both methods provide comparable significant improvement regarding metabolic equivalents as well as abdominal fat content.

An exemplary study regarding strength training for health related physical activity is by Törpel, Peter, Kemmesies and Schega (2016). It could be demonstrated that, following a strength training session, a release of insulin-like growth factor 1 (IGF-1) takes place, which, among other functions, regulates muscle hypertrophy. In this regard, positive effects could be detected with low to moderate intensity with venous stasis in older adults. The professional journal '*Zeitschrift für Sportpsychologie*' dedicates the issue 2/2017 to the topic of 'dance therapy'. The overview by Bräuninger (2017) on current research regarding dance and exercise therapy types of treatment for cancer patients is also of special interest. The overview shows that dance and exercise therapy interventions can be applied in all phases of cancer treatment. However, the amount of the research in this area is still inadequate, and tendencies could only be observed, and inferences made regarding overall effects of dance therapy in cancer treatment. Koch (2017) examines and discusses empirical results regarding effecting factors and how they work in dance and exercise therapy and develops a theoretical model.

Of particular interest within this reporting period are the published articles on the use of new media in the development of health related physical activity programs. The journal '*Bewegungstherapie und Gesundheitssport*' published a special issue on telemedical assistance systems (issue 4/2017). Internet based programs, such as picture oriented telerehabilitation, telerehabilitation in virtual settings and sensor based telerehabilitation appear to be quite promising. Aspects to be considered in this regard are; cost effectiveness of telerehabilitative approaches, possibilities of application with various patient groups, coordination with established conventional therapies and support for standardized and

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guideline oriented therapy processes. The central goal of telerehabilitative measures is to reach patients who, due to geographical restraints, immobility or time and/or financial limitations, are not able to take part in a sustainable, local rehabilitation programs. Reviews and research from Haupt, Wolschke, Rabe, Scholz, Smurawski, Salzwedel, Thomas, Reich, Völler, Liebach and Eichler (2016), John (2017), John and Einhaus (2017) as well as Mayer-Berger, Gatscher, Hekler, Kavelaars, Jakob, Simic and Stock (2017) provide evidence that telemedical assistance systems excellently meet the requirements of conventional therapy concepts. In particular, easy operation and light, playful forms of application make these systems useful and effective. It can therefore be implied that, with this form of intense care, the effectiveness of aftercare treatment can be increased overall.

Aside from the individual forms and content of intervention programs, the question arises regarding quality criteria such programs should fulfill. Henn, Karger, Wöhlken, Ungerer-Röhrich, Graf and Woll (2017) as well as Henn, Karger, Wöhlken, Meier, Ungerer-Röhrich, Graf and Woll (2017) presented overviews on examples of 'good-practice' regarding physical activity promotion for 'children and youth', 'adults' as well as 'older people'. They developed six quality criteria for the assessment of such projects (need analysis and target group, application, implementation, documentation, evaluation as well as sustainability and stabilization), with which the authors categorized previously researched projects as "good-practice" projects. However, as stated by the authors, the examples of 'good-practice' projects still contain deficits in the areas of documentation and sustainability.

### 3 *Effects of health related physical activity*

The important role of physical activity on health and subjective well-being is the initiating factor of the conceptualization of health related physical activity programs. For the area of workplace health promotion, Möglich (2017) compares synergies in the areas of motology and ergonomics and provides an overview for health promotion for production employees, while Nägele (2016) highlights the specific features of physical activity oriented workplace health promotion in small to medium sized businesses. Mastnak (2017) addresses the subject of overuse syndrome in sports as well as in the workplace. With the help of a comparative overview study, the author demonstrates that overuse syndrome can be triggered by similar workload patterns in certain sport disciplines and occupations. Rudolph, Göring and Kappmeier (2016) present the results of a systematic review regarding the effects of sport and physical activity related interventions in a workplace setting. The authors conclude that there is little documented evidence of long-term and effective physical activity programs in the workplace setting. Overall, 21 studies could be identified, mostly focusing on improvement of physical, mental, and social parameters as well as an increase in physical activity participation. Based on this review, these measures produce positive effects. Menzel, Drögemüller, Hartwig and Wollesen (2016) present the results of the EU-project "Fit for Business", which focuses on internal structures of workplace health management, health promotion and previous intervention programs in both German and Dutch small to medium sized businesses. Within the framework of the research association TRISEARCH, Schaller, Alayli, Altin, Biallas, Falkowski, Grieben, Nitzsche, Pförtner, Pfaff, Stock and Froböse (2016) focus on the evidence base regarding quality of prevention programs addressing lifestyle associated illnesses.

As in the previous years, publications addressing secondary prevention through physical activity concentrate on cardiovascular diseases. Berckhan, Schwan and Woll (2016) provide an overview on the effects of various sports therapeutic training methods with patients with heart failure. Based on the evaluation of 135 studies published between 1991 and 2015, it could be concluded that the effects of endurance training interventions have been well studied, while strength and interval training have not yet been sufficiently investigated. Löbel, Schwan, Nechwatal and Woll (2017) examined the effects of inspiratory muscle training in patients with heart failure. Another aspect was assessed by Kloss, Nechwatal, Schwan and Woll (2017) with their discussion on problems with the application of heart rate formulas for directing training in cardiac rehabilitation. Based on the secondary analysis of international guidelines in cardiology practice, the authors could demonstrate that the practice oriented formulas have only limited application. In their study, Sammito and Böckelmann (2017) examined both age and gender specific reference values for application of heart rate variability in movement therapy. Based on a comprehensive sample group of 673 healthy subjects, the results reveal a general decrease in heart rate variability with increasing age and differing variability between women and men. The research group critically points out that, due to the low number of subjects under the age of 20 and over the age of 60, it was not possible to provide corresponding reference values.

In addition to the leading cardiovascular diseases observed in morbidity statistics, other selected medical conditions and the extent to which they can be influenced by exercise and/or sports therapy have

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been taken into consideration. Particularly interesting during this reporting period is the monography by Bonadt (2016), focusing on Metabolic Syndrome. This study examines to what extent the risk of developing Metabolic Syndrome can be reduced by being physically active. The data analysis of 737 subjects reveal that people who are physically active and fit demonstrate fewer characteristics of Metabolic Syndrome than people who are inactive and not fit. The risk for ‘non-athletes’ to develop this syndrome is five times higher than for athletes, and for people who are not physically fit, even ten times higher than for those who are.

The effects of physical activity on the risk of cancer as well as the influence on the progression of the disease are documented, for example by Humm and Baumann (2016), who discuss the meaning of therapeutic riding in oncology. Becker and Schega (2016) emphasize the meaning of exercise therapy in the treatment of bladder cancer. Schröder, Kohlmann, Neugebauer, Schmid and Hebart (2016) analyze the attitudes of tumor patients regarding supplementary treatment with sports and physical activity programs. Results from guided interviews and a structured questionnaire allow the conclusion that, aside from personal and social resources, both physical fitness level and living proximity to the programs available are key factors in providing such supplementary treatment. Wiskemann and Dehler (2016) observe a significant decline in physical activity participation of colorectal cancer patients without therapeutic support during the primary treatment phase.

Another area of focus during this reporting period is sports related publications regarding physical conditions and illnesses of the skeletal system. Based on a narrative review, Giesche, Kalo and Vogt (2017) show that preoperative physical training in patients with knee and hip replacements positively influences “clinic stay as well as a quicker recovery towards daily tasks”. Kurz, Gosenheimer, Schumann-Schmid, Steinmetz and Schöllhorn (2016) were able to prove the positive effects of differential gait training for in-patients after knee or hip TEP.

The effects of movement and sport on less studied medical conditions are discussed by, for example, Limbach and Wehrle (2016), who examine the preservation of endurance and mobility during allogeneic hematopoietic cell transplantation. The results indicate that, despite exercise therapeutic intervention – one group completed endurance exercise and the second balance training – the procedure leads to a decline in physical capability. Physical systems are influenced too strongly during and immediately after an allogeneic hematopoietic cell transplantation, hindering adaptation ability of the cardiovascular und musculoskeletal systems.

#### **4      *Health related physical activity with children and youth***

In the area of health related physical activity with children and youth, several articles have been published within this review period that address topics such as motor performance ability, athletic activity and health of children and youth. Of particular interest during this reporting period are the publications surrounding the so-called MoMo-Study; a representative longitudinal study as part of the German Health Interview and Examination Survey for Children and Adolescents, which has been collecting data since 2003 on physical activity, motor performance ability as well as various health parameters of children and youth. The overview article by Albrecht, Hanssen-Doose, Bös, Schlenker, Schmidt, Wagner, Will and Worth (2016) is noteworthy, in which a six year cohort study (2003-2009) provides the authors with a basis to review the changes in motor performance ability. The data shows that the motor performance of children and adolescents in Germany did not decrease within the observational period. In addition, the cross-sectional and longitudinal assessments, demonstrate that improvements in motor performance ability coincide with better overall well-being; although this could only be partly confirmed for feminine participants (Hanssen-Doose, Albrecht, Oriwol, Hölling & Worth, 2016). Based on data from this six year observation period, Schmidt, Will and Woll (2016) observed an eight percent increase in physical activity participation in schools and organized sports clubs. The aspect was further examined by Will, Schmidt and Woll (2016), who could demonstrate social differences regarding extracurricular physical activity programs in schools. Albrecht, Hanssen-Doose, Oriwol, Bös and Worth (2016) showed that, based on a detailed evaluation of the data, changes in body composition (body-mass-index) influences the development of motor performance ability; smaller increase in performance with children and youth who are overweight and adipose than with those of average weight. As part of the German Health Interview and Examination Survey for Children and Adolescents (KiGGS Wave 1) Kuntz, Frank, Manz, Rommel and Lampert (2016) collected data regarding social determinants influencing the ability to swim of children and youth (N=9750). The results clearly show that 14.5 % of children between the ages of 5 and 17 do not know how to swim. Children and youth coming from a lower social status are less likely to be able to swim than

those coming from a higher social status. Adolescents with an immigration background are also less likely to know how to swim than their peers without an immigration background.

Greier, Ruedl and Riechelmann (2017) address the question if “immigration background is an independent contributor to physical fitness in children and adolescents” (p. 256). The results reveal that a lower level of physical fitness in children from Tyrol between the ages of 6 and 14 with immigration background can be explained by less participation in sports clubs, a personal TV device in their room and a higher BMI. However, the results are from a cross-sectional study and can therefore only be interpreted to a limited extent as significant. How students from a vocational school assess the intensity of personal physical activity is examined with a cross-sectional study by Rudolf, Schaller, Frick, Grieben and Froböse (2016). They were able to show that the students have an inaccurate self-assessment of personal physical activity. Respectively, 45.3 % of the students over and under estimated their personal physical activity. This is demonstrated by the weak correlations ( $r=0.40-0.49$ ;  $p<0.05$ ) between subjective and objective data.

Physical inactivity, i.e. mainly a ‘sitting’ lifestyle, has been increasingly discussed within sports and health sciences in the last years, especially as part of the collaborative action campaign, ‘Platform nutrition and movement’ (peb). For this reporting period, the study by Huber and Köppel (2017) is relevant in this regard, which revealed shocking results on time children and youth between the ages of 4 and 20 spent sitting. The average time spent sitting is 10.58 hours ( $SD = 2.68$ ) per weekday and 7.52 ( $SD = 2.20$ ) per weekend day; therefore 71 % and 54 % respectively. The need for intervention regarding physical activity promotion of children and youth is also confirmed by both Wirsik, Sprengeler, Brandes and Pohlabein (2017) as well as Klein, Pitsch and Emrich (2016).

Relevant to the topic of health promotion in educational institutions, such as kindergartens and schools, many articles on intervention measures for stress management and motor performance were published within this reporting period. In their study, Schmid, Schröder, Eschenbeck and Kohlmann (2016) assume that children and youth can learn and apply coping strategies to help with emotional regulation. In addition to increased stress tolerance, improvements can be observed in physical performance and personal resources, such as self-confidence. Aspects of body awareness are receiving more attention within subject specific health promotion programs. Müller (2016) focuses on the implementation of ‘short relaxation programs’ in a primary education setting in his intervention study ( $N=946$ ). With consideration of current research and based on quantitative-qualitative analyses of primary educational plans in Germany, child friendly physically based relaxation units were developed and the implementation scientifically accompanied in selected kindergartens. The evaluation does not only consist of observations and interviews of the participating children, kindergarten teachers and parents, but also psychophysiological assessments to measure the effects of relaxation in pre-school children. The results demonstrate that child appropriate relaxation programs can be successfully integrated into the daily kindergarten routine. Furthermore, significant health promoting effects can be observed with the use of such programs. Within this reporting period, the research group ‘Karlsruhe Relaxation Training’ presented practice oriented publications focusing on programs for ‘awareness training’ for children (cf. Fessler & Knoll, 2016a, b, c). In addition to the articles presented on primary prevention, there have once again been articles published in the past couple of years which focus on secondary prevention that address the influence of physical activity on various illnesses in children and youth. Regarding overweight and obesity (among others: Graf, 2016; Schienkiewitz, Brettschneider, Schaffrath Rosario, Lange & Kurtz, 2016), the article by Aue, Finne and Bucksch (2016) is noteworthy, in which the “meaning of physical activity behavior, sitting behavior and nutrition for health in early childhood” is highlighted. The importance of physical activity promotion in the treatment of children and youth with cancer is shown by Kesting, Götte, Seidel, Müller, Michel, Krüger, Rosenbaum and Boos (2016), while Böhlke and Müller (2016) discuss the possibilities of sport and exercise based projects in the context of youth with mental illness.

## 5 *Health-related physical activity with adults and seniors*

From a sports scientific point of view, physical activity, fitness and health are considered central elements across an individual’s lifespan. In research surrounding physical fitness and adults, the topic of ‘fasciae’ becomes more interesting. Krause, Wilke, Vogt and Banzer (2016), Schröder, Renk, Lohr and Braumann (2016), Pohl, Brauner, Klitzke, Liefke, Horstmann and Horstmann (2016) examine the effectiveness of a Self-Myofascial-Release-Training with a rigid foam roll. Wilke, Vogt, Niederer and Banzer (2016) studied the effects of local and non-local stretching of myofascial tissue. Flexibility exercises of the lower limbs (defined as below the superficial back line) can lead to increased

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cervical range of motion. This is assessed with the support of an ultrasonic optometric 3D motion analysis system

There are also many publications during this reporting period that address the population of older adults. Neumann (2017) gives an overview on resilience and physical performance for adults over the age of 60: the obvious decrease in performance is dependent on muscle degeneration and a decreasing maximum oxygen intake and heart rate. Müller, Rehfeld, Lüders, Schmicker, Hökelmann, Kaufman and Müller (2016) researched the effects of both dance training and health related exercise on neuroplasticity of healthy seniors. It could be shown that, after 18 months of training intervention, an increase in volume, especially in the frontal and temporal regions of the brain, took place. In the exercise group, the increase in volume was observed in the subcortical regions. In comparing the two sets of results, it becomes obvious that participating in a long-term dance program is superior to an exercise program for inducing neuroplasticity in the brains of seniors, also since the regions affected by dance training are associated with higher cognitive functions.

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