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Review

Effects of physical activity on the symptoms of Tourette syndrome: A systematic review

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ABSTRACT

There is irrefutable evidence that routine physical activity or exercise can offer considerable health benefits to individuals living with various mental disorders. However, it is not clear what effect physical activity has on the symptoms of Tourette syndrome. Despite a paucity of evidence, physical activity or exercise has already been recommended by various health organizations for the management of tics. We provide a systematic review of the effects of physical activity or exercise on tic symptomology in individuals with Tourette syndrome. Major electronic databases were searched for all available publications before August 2017. Keywords and MeSH terms included "physical activity" or "exercise" or "exercise therapy" or "physical exertion" or "sports" and "tics" or "tic disorders" or "Tourette." Eight studies were included, the majority of which were case reports. Despite a number of methodological limitations of the included studies, the review points to a trend that the effects of acute physical activity are intensity-dependent, where light intensity may alleviate and vigorous intensity may exacerbate tics. Chronic physical activity, however, appears to reduce the severity of tics even at higher intensity. Several physiological mechanisms may explain the differential effects of acute and chronic physical activity in Tourette syndrome. Future randomized controlled studies should better characterize the effects of different intensities and types of physical activity in Tourette syndrome.

1. Introduction

Tic disorder is a neuropsychiatric condition characterized by short-lasting, sudden, habitual, non-rhythmic muscle contraction (motor tics) or vocalization (phonic tics) [1]. Tourette syndrome (TS) is diagnosed when both motor and phonic tics are present for at least one year [1]. The overall international prevalence of TS is approximately 1% [2]. The onset of tics is usually between 4 and 6 years of age, with peak severity occurring between ages 10 and 12 years [1]. In the majority of children with TS, symptoms generally diminish or disappear as adults, but a small percentage (approximately a third) will have persistent symptoms that require clinical attention [1,3].

Several neural mechanisms have been proposed for TS. The observation that antipsychotics (i.e., agents that block dopamine D_2 receptors) have been effective in treating tics has led to a hypothesis that heightened dopaminergic activity may be involved in TS [3]. Studies using positron emission tomography further demonstrated elevated striatal dopamine release in individuals with TS [4,5]. In addition, alpha$_2$-adrenergic agonists (e.g., clonidine) that inhibit the release of norepinephrine have also been effective anti-tic medications [3], suggesting heightened central noradrenergic activity in TS [6]. Studies that examined cerebrospinal fluid biogenic amines further demonstrated elevated levels of norepinephrine in TS patients compared with healthy individuals [7]. Moreover, stress-related neurobiological mechanisms seem to play a role, as evidenced by elevated cerebrospinal fluid levels of corticotropin-releasing factor in patients with TS [8]. This further suggests that there may be secondary sympathetic activation as well as elevated beta-endorphin release [9]. Alterations in other neurotransmitter, including cholinergic, gamma-aminobutyric acid (GABA)-ergic, and serotonergic, systems are also thought to play a role in the pathophysiology of TS [10].

Although pharmacological treatment can be effective for the symptoms of TS, use of medications, such as antipsychotics

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andalpha$_2$-adrenergic agonists, can be limited by their side effects [3]. In particular, antipsychotics are known for their cardiovascular, metabolic, and neuro-motor side effects [3]. There have also been rare cases of antipsychotic-associated worsening of pre-existing tics or induction of new tics in individuals with tic disorders [11,12]. Therefore, alternative or adjunct nonpharmacological treatment can be of substantial value in people living with TS. For instance, behavioral therapy that involves tic-awareness (i.e., observing the premonitory urge or other signs preceding the occurrence of a tic) and competing-response (i.e., engaging in a voluntary behavior that is physically incompatible with the tic to manage the premonitory urge) training has already demonstrated efficacy in TS [13]. A recent meta-analysis of 8 randomized controlled trials (N = 438) revealed a medium-to-large treatment effect for behavioral therapy in persons with TS [14].

However, little is known about physical activity (PA) or exercise. Although routine PA has demonstrated efficacy in a number of mental disorders [15], limited evidence exists for TS. To our knowledge, there is no randomized controlled trial examining the effects of PA or exercise in TS. Questionnaires and self-reports have revealed that PA was helpful in attenuating tics in up to 32% of youth and adults with TS [16,17]. In other studies, however, PA as an attenuating factor was endorsed only in 7-9% of cases [18]. Despite such a paucity of evidence, some health organizations have already been promoting PA for the management of tics [19–22]. Although there is irrefutable evidence of health-related benefits associated with routine PA [23], more evidence seems to be required for TS. We conducted a systematic review of the literature to better characterize the effects of PA or exercise, either acute or chronic, on the symptoms of TS.

2. Methods

2.1. Data sources and searches

This systematic review was conducted on the basis of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [24]. A comprehensive search of the literature was performed using the Medline, Embase, and PsycINFO databases to find all available publications until 12 August 2017. Reference lists from identified studies were also examined. Keywords and MeSH terms used were as follows: “physical activity” or “exercise” or “exercise therapy” or “physical exertion” or “sport*” and “tics” or “tic disorder*” or “Tourette*.”

2.2. Eligibility criteria

To be included in our systematic review, studies had to meet the following criteria: i) participants were diagnosed with tic disorders or TS, ii) participants were exposed to certain types of PA or exercise, iii) the outcome measure included the change in severity or frequency of tics in response to PA or exercise, and iv) randomized controlled trials, observational studies, and case reports were included. Studies were not excluded on the basis of age, sex, or ethnicity of participants. Studies were excluded if the type of PA or exercise protocol was not specified.

2.3. Data extraction

Descriptive data were extracted according to: i) author, year, country, study design, sample size, sex, age, diagnosis, and medication, ii) type of PA or exercise or training protocol, and iii) change in severity or frequency of tics in response to PA or exercise. If the intensity of PA or exercise was not specified by the study, we referred to the 2011 Compendium of Physical Activities to obtain a metabolic equivalent (MET) value for a certain type of PA and then the 2011 American College of Sports Medicine Position Stand to identify the absolute intensity of the given MET value [25,26].

3. Results

Out of 343 studies screened, 8 studies were included in this review (Fig. 1). Of the 8 included studies, 5 studies reported the effects of acute PA [27–30,33], and 4 studies reported the effects of chronic PA on tic symptomology [31–34]. The studies are summarized in Table 1 and in detail in the following section. Overall, there was a trend that the effects of acute PA are intensity-dependent, where light intensity may alleviate and vigorous intensity may exacerbate tics. Chronic PA, however, appears to improve tics even at higher intensity. The relationship between PA intensity and tic expression is presented in Table 2. Lastly, there is some evidence that tics remain reduced after exercise but tends to be short-term.

3.1. Effects of acute physical activity

3.1.1. Light intensity

In the study by Nixon et al. [30], 18 young participants with TS (13 male, 5 female; age range: 10–20 years) completed an acute bout of aerobic exercise (i.e., aerobic kickboxing) at an easy followed by a more cognitively demanding (hard) level. Six of the 18 participants were being treated with one or a combination of 2–3 medications, including clonidine, aripiprazole, risperidone, and sertraline. Although the exercise session was designed to be moderately vigorous, participants overall performed at 43–63% of their estimated maximum heart rate (HR_{max}), which is estimated to be of light intensity according to the 2011 American College of Sports Medicine Position Stand [26]. Compared with baseline, there was a significant reduction in tic frequency during the exercise session ($p = 0.001$) as well as during the post-exercise session ($p = 0.039$). The authors noted that the reduction was greater during the easy than the hard level ($p = 0.022$); however, because the hard level was always followed by the easy level, the differential impact of the two tasks was difficult to establish [30]. The authors attributed the overall reduction in tic frequency to the activation of executive control circuits, sensory/motor tricks (i.e., gestes antagonistes), and/or reduced anxiety associated with exercise [30].

Garcia-Ruiz and del Val [29] reported a case of a 76-year-old woman with chronic motor tics, who had been treated with tetrabenazine 12.5 mg tid. It was reported that a complete disappearance of her tics was noted when she engaged in sweeping floors. Sweeping may require intensities ranging from 2.3 METs (light intensity) to 3.8 METs (moderate intensity) for a 76-year-old woman [25,26]. According to the supplementary video provided by the authors, it can be estimated that the woman was sweeping at light intensity. Other chores, such as ironing (1.8 METs) [25], were also reported to partially attenuate her tics. The attenuating effect of sweeping on tic expression was attributed to its complex action that involves axial dorsal and cervical muscle groups, which may serve as a sensory/motor trick [29].

Liu et al. [33] reported a case of a 12-year-old boy with TS. The child complained of pain in his lower extremities, for which he went through a 3-month physical therapy program. It was reported that the child frequently engaged in the prescribed stretching exercises to inhibit his tics. Mild stretching generally requires 2.3 METs, which is equivalent to light intensity [25,26]. The