REVIEW / SYNTHÈSE

Evidence-based risk assessment and recommendations for physical activity clearance: cognitive and psychological conditions[1]

Ryan E. Rhodes, Viviene A. Temple, and Holly A. Tuokko

Abstract: Physical activity has established mental and physical health benefits, but related adverse events have not received attention. The purpose of this paper was to review the documented adverse events occurring from physical activity participation among individuals with psychological or cognitive conditions. Literature was identified through electronic database (e.g., MEDLINE, psychINFO) searching. Studies were eligible if they described a published paper examining the effect of changes on physical activity behaviour, included a diagnosed population with a cognitive or psychological disorder, and reported on the presence or absence of adverse events. Quality of included studies was assessed, and the analyses examined the overall evidence by available subcategories. Forty trials passed the eligibility criteria; these were grouped (not mutually exclusively) by dementia ($n = 5$), depression ($n = 10$), anxiety disorders ($n = 12$), eating disorders ($n = 4$), psychotic disorders ($n = 4$), and intellectual disability ($n = 15$). All studies displayed a possible risk of bias, ranging from moderate to high. The results showed a relatively low prevalence of adverse events. Populations with dementia, psychological disorders, or intellectual disability do not report considerable or consequential adverse events from physical activity independent of associated comorbidities. The one exception to these findings may be Down syndrome populations with atlantoaxial instability; in these cases, additional caution may be required during screening for physical activity. This review, however, highlights the relative paucity of the reported presence or absence of adverse events, and finds that many studies are at high risk of bias toward reporting naturally occurring adverse events.

Résumé : L'activité physique procure, on le sait, des bienfaits pour la santé physique et mentale; toutefois, il y a peu d'études sur les effets nocifs. Cet article se propose d'analyser les documents portant sur les effets nocifs associés à la pratique de l'activité physique chez les personnes présentant des troubles d'ordre psychologique ou cognitif. On localise les documents dans les bases de données informatiques, par exemple MEDLINE, psychINFO. Les études retenues devaient traiter des effets d'une modification de comportement en faveur de la pratique de l'activité physique, devaient concerner une population présentant cliniquement un trouble psychologique ou clinique et devaient rapporter la présence ou l'absence d'effets nocifs. On évalue la qualité des études répertoriées et on analyse la preuve scientifique globale pour les sous-catégories disponibles. Quarante essais cliniques passent le test d'admissibilité et se répartissent dans les groupes suivants (non mutuellement exclusifs) : démence ($n = 5$), dépression ($n = 10$), troubles d'anxiété ($n = 12$), troubles alimentaires ($n = 4$), psychose ($n = 4$) et déficience intellectuelle ($n = 15$). Toutes les études présentent un risque de biais potentiel allant de modéré à élevé. D'après les observations faites, le taux de prévalence des événements nocifs est faible. Les études sur les populations présentant de la démence, des troubles psychologiques et de la déficience intellectuelle ne rapportent pas beaucoup d'effets nocifs associés à la pratique de l'activité physique, et ce, indépendamment des comorbidités associées. La seule exception à ces observations concerne les populations atteintes du syndrome de Down et présentant une instabilité atloïdo-axoïdienne; pour ces cas, il faut porter une attention particulière lors du dépistage en matière d'aptitude à l'activité physique. Toutefois, l'analyse documentaire souligne le manque d'indication relative à la présence ou l'absence d'événements nocifs; de plus, cette analyse constate le haut risque de biais quand il s'agit de rapporter des événements nocifs se présentant normalement.

[Traduit par la Rédaction]

Received 11 November 2010. Accepted 16 March 2011. Published at www.nrcresearchpress.com/apnm on 29 July 2011.

R.E. Rhodes and V.A. Temple. School of Exercise Science, Physical and Health Education, University of Victoria, Victoria, BC V8W 3P1, Canada.
H.A. Tuokko. Department of Psychology, University of Victoria, Victoria, BC V8W 3P5, Canada.

Corresponding author: Ryan E. Rhodes (e-mail: rhodes@uvic.ca).

[1]This paper is one of a selection of papers published in this Special Issue, entitled Evidence-based risk assessment and recommendations for physical activity clearance, and has undergone the Journal's usual peer review process.

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Introduction

The purpose of this paper was to review the documented events occurring from participation in physical activity among populations with psychological or cognitive conditions. This represents a large and diverse field; thus, we have focused specifically on high-prevalence conditions, severe conditions, and conditions in which physical activity may serve to benefit these populations most in terms of benefit to risk assessment, based on previous work (Durstine and Moore 2003). For the purpose of discussion and organization, these conditions have been grouped as dementia, psychological disorders, and intellectual disability, and will be discussed in this form throughout.

Prevalence and significance of dementia

The term dementia refers to an overall decline in mental capacity that renders the person unfit to meet the diverse cognitive demands associated with everyday living. Most conditions producing this behavioural syndrome are progressive, and they produce devastating effects for those afflicted, their families, and society. The prevalence of dementia was estimated to be 8% of all Canadians aged 65 and older in 1991. The age-standardized prevalence rate was shown to increase from 2.4% among those 65–74 years of age, to approximately 11% among those 75–84 years, and 34.5% among those 85 years and older (Canadian Study of Health and Aging Working Group 1994). Given this dramatic shift in prevalence with age and the anticipated universal rise in the proportion of the population that will live well beyond 65 years, it is imperative that the impact of the dementia on all aspects of functioning, including physical activity, be considered.

Types of dementia

A dementia or dementia-like syndrome may be produced by many different underlying neurological disorders. The conditions responsible for the majority of cases of dementia are Alzheimer's disease (AD) (in 5.1% older than 65 years) and vascular dementia (in 1.5% older than 65 years) (Canadian Study of Health and Aging Working Group 1994). They differ not only with respect to the underlying neuropathology, but also with respect to the onset and course of deterioration. AD, like many other form of dementia, has an insidious onset and a slowly progressive nature, whereas vascular disorders are often characterized as more likely to have a sudden onset and stepwise progression with periods of stability that can last for years (Tuokko and Hadjistavropoulos 1998).

Less common conditions that can give rise to dementia include disorders affecting subcortical regions of the brain, such as progressive supranuclear palsy, Huntington's disease, Parkinson's disease, Lewy body disease, and normal pressure hydrocephalus. These disorders typically affect motor functions, and presenting symptoms can include bradykinesia (i.e., slowed movements), rigidity, poor coordination and unsteadiness of gait, a variety of hyperkinesias (such as tremor, chorea, myoclonus, and tics), and dysarthria.

Dementia symptoms

Central to this behavioural syndrome of dementia, as defined by the Diagnostic and Statistical Manual for Mental Disorders, fourth edition, text revision (DSM-IV-TR) (American Psychiatric Association 2000), is memory impairment. At least one other area of cognitive functioning must show evidence of impairment. These other cognitive domains include disturbances of language (aphasia), motor planning (apraxia), visual perception and recognition (agnosia), and executive functions. Executive functions refer to those capacities that enable a person to engage in independent, purposive, and self-serving behaviour. Disorders that affect executive functions compromise the development of strategies to approach, plan, and carry out activities, or result in defective self-monitoring of performance. A person with a disorder affecting executive functions may lack initiative or be unable to plan or carry out activity sequences that make up goal-directed behaviours. This is often in marked contrast to their performance in highly structured settings, where the plan is provided by the environment itself or by other people directing the activities. Thus, impairment in self-monitoring, self-regulation, and self-awareness is characteristic of those with disorders affecting executive functions.

The progressive deterioration in brain function that typically underlies the dementia syndromes leads to increasing impairment and dependency, with the final stages of dementia leaving the individual "bereft of mental powers, unable to understand, communicate or reason, needing everything done for [him or her], incontinent and chairbound" (Jacques and Jackson 2000). Over time, dementia can come to affect every aspect of a person's life (e.g., ability to learn, ability to attend and concentrate, communication, judgment, self-control, emotion regulation, imagination). This progressive damage to widespread areas of the brain eventually leads to death (Corey-Bloom 2000). For the most common disorders that produce dementia (i.e., AD, vascular dementia, dementia with Lewy bodies), the symptoms can take anywhere from 5 to 15 years to manifest (Jacques and Jackson 2000).

It is important to note that different syndromes of cognitive and behavioural functioning exist as precursors to dementia or once dementia (i.e., memory impairment and impairment in another cognitive domain) has been identified. These syndromes may or may not be linked to specific etiologies (Tuokko and Hadjistavropoulos 1998). Syndromes presenting as mild and (or) focal include amnestic disorders (e.g., amnestic mild cognitive impairment, Wernicke-Korsakoff syndrome), language disorders (e.g., primary progressive aphasia), disorders primarily affecting behaviour (e.g., frontotemporal dementia), disorders primarily affecting movement (e.g., subcortical dementias, such as progressive supranuclear palsy, Huntington's disease, Parkinson's disease, Lewy body disease), and normal pressure hydrocephalus, which presents with the classic triad of gait disturbance, confusion, and incontinence. As the underlying neuronal condition worsens and more areas of functioning become impaired, it becomes more difficult to distinguish conditions on the basis of cognitive performance, and management issues become the focus of the affected individuals and their care providers (i.e., family or staff). While an individual with dementia may experience severe impairment of mental abilities, their physical abilities and health may remain relatively intact until quite late into the illness (Jacques and Jackson 2000). It can become quite challenging to maintain and promote physical activity for people who cannot plan

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

or monitor their own behaviour, yet who have the capability, and often desire, to engage in demanding physical exercise.

Management of dementia

The deterioration in cognitive, behavioural, and social functions associated with dementia and its precursors are interdependent and interact. Not surprisingly, it has been observed that the types of everyday problems (i.e., social and behavioural) experienced by people with these disorders tend to mirror the presenting cognitive deficits (Tuokko 1993). For example, a person with pronounced memory impairment relative to other cognitive deficits also shows deficits in everyday behaviours reflective of underlying memory impairment (i.e., remembering new information, such as conversations, messages, appointments). Tasks that are highly complex and cognitively demanding are likely to be the first areas of functioning to be compromised (e.g., financial management, driving).

Over the past 2 decades, research has emerged examining the effects of anti-dementia drugs. Although progress has been made, there is, as yet, no cure for any of the underlying causes of dementia. At least for the foreseeable future, the impact of pharmacological approaches to slow, stop, or reverse underlying pathological changes is likely to be partial, at best, and they will not be applicable in many cases (Clare and Woods 2001). Yet, there are helpful behavioural approaches to management that may or may not be relevant to specific underlying neuropathology.

One common approach for determining appropriate management strategies is to examine the types of deficits manifest and then to select management strategies specific to these deficits. For example, very early in the course of a dementia, the evident memory impairment may be a circumscribed retrieval deficit, with acquisition and retention of material remaining relatively intact. The provision of cues in the environment (e.g., calendar in visible place) may prove sufficient to prompt and support the retrieval of salient information. Other problems that may occur early in the course of a dementia, such as accomplishing complex household tasks (e.g., programming the DVD recorder) or operating complex devices (e.g., ATM machines), may occur; guidance or assistance may be required if the task cannot be simplified. As memory problems become more pervasive, strengthening the initial encoding of new information through repetition may prove useful. It has been shown that the see, say, do approach (have the person with dementia observe a task being performed, verbalize the sequence of steps to perform the task, and imitate the performance of the task) results in better recall of the task than any one of these components alone (Gallie et al. 1990).

In addition to approaches to management based on an understanding of the presenting cognitive and behavioural syndromes, rehabilitative strategies can be undertaken with a focus on maximizing functioning across many areas, including psychological well-being, living skills, and social relationships (Clare and Woods 2001). These rehabilitative approaches are based in biopsychosocial models of dementia care, and aim to enhance self-efficacy and coping skills, combat threats to self-esteem, and help the person make the best possible use of available resources (i.e., internal and external to the individual). This area of research is relatively new, but already the emerging evidence strongly supports the relevance of cognitive rehabilitation strategies for people with dementia and their families (Clare and Woods 2001).

It has been observed that, in addition to optimizing functioning and well-being, behavorial interventions may delay the emergence of clinical and functional impairments. It has been proposed that the experiences gained through exposure to cognitive rehabilitation may dynamically influence the development and function of neural substrates (Stern 2002). Some work involving neuroimaging techniques is emerging to support this contention, and it is becoming increasingly important that both pharmacologic and behavioural intervention studies focus on both behavioural and biological outcomes.

Another intervention approach that has been found to improve cognitive functions and influence brain functions in animal models of dementia, as well as in older adults without AD, is aerobic exercise (Yu et al. 2006). Aerobic exercise has been shown to prevent or delay age-related cognitive impairment or dementia (Rockwood and Middleton 2007), decrease brain tissue loss, and increase cerebral vasculature and blood flow in frontal, parietal, and temporal cortices (Kramer and Erickson 2007; Kramer et al. 2004). Moreover, results from a meta-analysis revealed striking improvement in executive functioning after older adults without AD participated in aerobic exercise (Colcombe and Kramer 2003). Few studies have focused on aerobic exercise in people with AD. Those that exist are limited and vary greatly in the exercise programs tested and outcomes measured. However, they suggest that aerobic exercise can enhance cognitive function and delay functional decline (Palleschi et al. 1996; Rolland et al. 2000). Moreover, exercise programs have been effective in improving a variety of health outcomes in people with AD (Landi et al. 2004; Teri et al. 2003).

Prevalence, etiology, and significance of psychological disorders

Psychological disorders are conceptualized as clinically significant behavioural or psychological syndromes or patterns that occur in an individual and that are associated with present distress or disability, with a significant probability of risk for death, pain, disability, or loss of freedom (American Psychiatric Association 2000). The mind–body split implied by the terms "psychological" and "mental" is acknowledged as a forced construction and semantics used merely by tradition. The etiology of psychological disorders is complex, and most researchers and clinicians conclude that it can be the consequence of genetic, biological, social, environmental, and cultural factors. This collection of disorders includes, but is not limited to, psychotic disorders (e.g., schizophrenia), mood disorders (e.g., depression), anxiety disorders (e.g., panic disorder with or without agoraphobia, phobias), dissociative disorders (e.g., amnesia), eating disorders (e.g., anorexia nervosa), personality disorders (e.g., obsessive-compulsive disorders), and adjustment disorders.

Excluding specific phobias like social phobia (e.g., public speaking), major depression has the highest prevalence of all mental illnesses in the population. The disorder afflicts more females than males, and has a prevalence of 5%–9% (DSM-IV-TR). Major depression has a significant impact on inter-

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

personal and occupational lifestyle, and is associated with high mortality; 15% of those diagnosed die by suicide. Generalized anxiety has the second highest prevalence in terms of mental illness; it afflicts approximately 3% of the population at any single time. The disorder has a considerable impact on the individual, often shaping behavioural avoidance. Arguably, the most severe mental illnesses are schizophrenia and other psychotic disorders. These disorders afflicts approximately 0.05% to 1.50% of the population, and are marked by severe impairment in social functioning. Finally, eating disorders are potentially important in physical activity considerations because of their link with exercise dependence and energy balance. Anorexia nervosa is characterized by refusal to maintain a minimally normal body weight; bulimia nervosa is marked by repeated episodes of binge eating, misuse of laxitives, fasting, or excessive exercise. Anorexia nervosa affects 0.5% of females; the lifetime prevalence of bulimia nervosa is 1.0%–3.0% (American Psychiatric Association 2000).

Symptoms of psychological disorders

In terms of depression, a major depressive episode is marked by at least 5 chronic symptoms, 1 of which must be depressed mood or lack of interest or pleasure for 2 weeks (American Psychiatric Association 2000). The other symptoms may include weight or appetite changes, insomnia or hypersomnia, psychomotor agitation or retardation, fatigue, self-reproach, diminished ability to think or concentrate, and recurrent thoughts of death. Generalized anxiety is marked by excessive worry or apprehension, occurring often for at least 6 months, about a number of activities, and the difficulty controlling this worry. These are expressed in 3 or more of the following symptoms: restlessness, fatigue, difficulty concentrating, irritability, muscle tension, and sleep disturbance. Panic attack, an anxiety disorder that afflicts approximately 1.5% of the populace, has at least 4 distinct physiological symptoms (palpitations, sweating, trembling, shortness of breath, choking, chest pain, nausea, dizziness, fear) that start abruptly and peak after 10 min (American Psychiatric Association 2000). Schizophrenia is marked by signs of delusion, disorganized thinking and behaviour, lowered reactivity, alogia, affective flattening, and avolition that persist for at least a month, with some signs of the disorder persisting for at least 6 months (American Psychiatric Association 2000). Finally, anorexia nervosa is identified by a volitional refusal to maintain body weight (85% of expected weight) with intense fear of weight gain, disturbance of thoughts about one's body shape, and amenorrhea for at least 3 menstrual cycles. Bulimia nervosa is marked by eating large quantities of food in a discrete period of time with recurrent compensatory behaviour to prevent weight gain (American Psychiatric Association 2000).

Management of psychological disorders

Based on the mixed and often unclear etiology of psychological disorders, treatment often includes varied management techniques. Most severe forms of the disorders involve pharmacologic treatment. These include antidepressant medication (e.g., fluoxine, nefazodone), antianxiety or anxiolytic medication (e.g., diazepam, alprazolam), and antipsychotic medication (e.g., clozapine, risperidone) for depression, anxiety, and schizophrenia, respectively. Psychotherapy in the form of various cognitive-behavioural therapies, relaxation therapy, and group interactions are also common. In severe cases, adjuvant therapies, such as electroconvulsive therapy for major depression, are also used.

In direct relevance to this review, exercise is often used in the treatment of psychological disorders. Regular physical activity may have a useful adjuvant role alongside pharmacologic treatment in schizophrenia (Faulkner 2005; Faulkner and Sparkes 1999; Faulkner and Biddle 1999). The use of exercise and regular physical activity in the treatment of depression and anxiety, however, is most prevalent. This recommendation is based on strong evidence for the respective antidepressant and anxiolytic qualities of regular moderate-intensity physical activity in these populations. For example, Dunn et al. (2001) conducted a review of studies featuring participants with DSM-IV depressive and anxiety disorders in 9 cross-sectional epidemiological studies, 9 prospective epidemiological studies, and 19 quasi-experimental studies. Overall, the results suggested that physical activity at moderate intensity, across different time periods and with all modalities, was related to fewer depressive symptoms. A meta-analysis of 14 randomized controlled trials with participants reporting clinical depression (Lawlor and Hopker 2001) also paralleled these results (effect size $d = -1.1$), and the most rigorously controlled study to date found similar effects (Dunn et al. 2005). In terms of anxiety, the size of this effect has ranged from $d = -0.24$ to $d = -0.56$; the stronger effects were found for clinical levels of anxiety (O'Connor et al. 2000; Petruzzello et al. 1991). Thus, the evidence supports the effectiveness of exercise, along with standard pharmacologic and psychotherapy management, for the 2 most prevalent psychological disorders.

Prevalence and significance of intellectual disability

Intellectual disability is "a disability characterized by significant limitations both in intellectual functioning and in adaptive behaviour as expressed in conceptual, social, and practical adaptive skills. This disability originates before age 18" (American Association on Mental Retardation 2002, p. 8). Intelligence tests and scales assessing adaptive behaviour estimate the degree of intellectual disability. In terms of intelligence, diagnosis of intellectual disability refers to intelligence quotient scores 2 standard deviations below the mean on a standardized assessment instrument. With reference to adaptive behaviour, diagnosis of intellectual disability refers to significant limitations in 1 of 3 areas (cognitive, social, or practical skills) or an overall adaptive behaviour score that is 2 or more standard deviations below the mean (American Association on Mental Retardation 2002). Approximately 3% of the world's population has some form of intellectual disability (World Heath Organization 2001); in Canada, the rate has been reported to be in the range of 1%–3% (Bradley et al. 2002; Ministry of Health and Welfare Canada 1988; Ouellette-Kuntz and Paquette 2001; Statistics Canada 2007) (including Down syndrome and mental impairment and excluding psychological conditions such as depression). Developmental disability has a broader definition than intellectual disability; the prevalence of developmental disability in Canada is more likely to be the higher prevalence (Bradley

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

et al. 2002; Ministry of Health and Welfare Canada 1988; Ouellette-Kuntz and Paquette 2001).

Etiology of intellectual disability

The etiology of intellectual disability is complex. Although there are several hundred known causes of intellectual disability, the etiology is unknown in 40%–60% of cases (Battaglia et al. 1999; Curry et al. 1997; Majnemer and Shevell 1995). In addition, more than 1 risk factor for intellectual disability is apparent among approximately half of the population diagnosed as having an intellectual disability (McLaren and Bryson 1987). The American Association on Mental Retardation (2002) uses a developmental, multifactorial approach to describe risk factors for intellectual disability. The broad categories of risk factors are biomedical, social, educational, and behavioural. These risk factors can interact with one another and change over time. Social and educational factors that are linked to intellectual disability include lack of intervention services, delayed diagnosis, inadequate stimulation, and inadequate family support. Behavioural risk factors for intellectual disability include prenatal exposure to drugs or alcohol, perinatal abandonment, and child abuse. Biomedical risk factors include chromosomal disorders, single-gene disorders, metabolic disorders, traumatic brain injury, prematurity, meningoencephalitis, and seizure disorders. Chromosomal abnormalities are a common cause of intellectual disability. For example, Down syndrome is predominately caused by trisomy of chromosome 21 and is present in 1 in 700 newborn children (Centers for Disease Control and Prevention 2006). Relatively small chromosomal deletions or duplications can also cause intellectual disability. For example, Prader-Willi syndrome (with an incidence of 1 in 10 000 live births) most often arises from an abnormality in paternal 15q11–13, and velocardiofacial syndrome (incidence of 1 in 4000 live births) typically results from a submicroscopic deletion of 22q11.2 (O'Brien et al. 2002).

Characteristics of intellectual disability

Individuals with intellectual disability have significant limitations in their general mental capability, including "reasoning, planning, problem solving, thinking abstractly, comprehending complex ideas, learning quickly, and learning from experience" (American Association on Mental Retardation 2002). In addition, they have significant limitations in skill areas, such as communication, self-care, social skills, health and safety, home living, community living, life-long learning, self-direction, and employment (Thompson et al. 2004; Wei et al. 2008). Individuals with intellectual disability have a high prevalence of health problems (see, for example, Kapell et al. 1998; van Schrojenstein Latman-De Valk et al. 2000), including sensory impairment (Beange 2002), epilepsy (Beange 2002), thyroid disease (Beange et al. 1995), obesity (Yamaki 2005), and osteoporosis (Center et al. 1998). They are 2.2 times more likely to have health problems than the general population, and individuals with more severe intellectual disability have a greater incidence of health conditions (van Schrojenstein Latman-De Valk et al. 2000) and earlier mortality (Patja et al. 2000) than those with mild intellectual disability.

Individuals with Down syndrome have different cardiorespiratory responses to exercise than individuals with intellectual disability who do not have Down syndrome (Pitetti and Fernhall 2005). In addition, a proportion of individuals with Down syndrome have cervical abnormalities that place them at risk of injury (Tassone and Duey-Holtz 2008). The phenotypic expression of Down syndrome differs widely; however, there are several syndrome-specific conditions that are common. Lennox (2002) provides a list of common medical conditions to aid general practitioners in the care of patients with Down syndrome. These conditions include visual and hearing impairment, hypothyrodisim, depression and Alzheimer's-type dementia, epilepsy (usually clonic or tonic), congenital heart defects (40%–50%), atlantoaxial instability, and skin disorders. Cervical spine abnormalities, such as atlantoaxial instability and atlanto-occipital instability, are well documented among people with Down syndrome (see, for example, Alvarez and Rubin 1986; Cremers et al. 1993). Depending on the criteria used, the prevalence of atlantoaxial instability among people with Down syndrome ranges from 10% to 40% (Alvarez and Rubin 1986; Cremers et al. 1993; Davidson 1988), and approximately 10% of people with atlantoaxial instability are symptomatic (Alvarez and Rubin 1986). Neurological symptoms of atlantoaxial instability include abnormal gait and difficulty walking, sensory deficits, spasticity, neck pain, torticollis or head tilt, and hypereflexia (American Academy of Pediatrics 1995). Evidence also indicates that people with Down syndrome exhibit low maximal heart rate or chronotropic incompetence (Baynard et al. 2004; Guerra et al. 2003). Baynard et al. (2004) report that the ability of individuals to increase heart rate at high exercise intensities is reduced in people with Down syndrome. suggest that this response is consistent with reduced sympathetic drive and circulating catecholamines; however, additional research is needed to fully explain this response.

Management of intellectual disability

Oullette-Kuntz and colleagues (2005) report that more than 30 health supervision guidelines have been developed for specific genetic disorders that result in intellectual disability. These guidelines assist in the anticipation of certain health problems, thereby facilitating the provision of appropriate care. However, overall, Ouellette-Kuntz et al. (2005) conclude that many Canadians with an intellectual disability have undiagnosed and untreated medical conditions and lack access to health services, including health-promotion initiatives. Increasing life expectancy among people with intellectual disability has shifted focus toward the health promotion and prevention of secondary disabling conditions (Rimmer 1999). As in the general community, people with an intellectual disability need a healthy lifestyle that includes adequate sleep, immunization, good nutrition, and physical activity.

Research consistently shows that individuals with intellectual disability are less fit than the general community, that levels of physical fitness are low (Fernhall and Pitetti 2001; Graham and Reid 2000; Pitetti and Yarmer 2002; Pitetti et al. 2001), and that the proportion of individuals who participate in physical activity at levels consistent with public health recommendations ranges from 17.5% to 33.0% (Temple et al. 2006). However, evidence also suggests that people with intellectual disability can improve muscular and cardiovascular endurance by participating in well-constructed exercise training (Chanias et al. 1998).

RIGHTSLINK

Table 1. Relative intensities for aerobic exercise prescription (for activities lasting up to 60 min).

Intensity	%HRR	%HR_{max}	RPE	Breathing rate	Body temperature	Example activity
Very light effort	<20	<50	<10	Normal	Normal	Dusting
Light effort	20–39	50–63	10–11	Slight increase	Starting to feel warm	Light gardening
Moderate effort	40–59	64–76	12–13	Greater increase	Warmer	Brisk walking
Vigorous effort	60–84	77–93	14–16	More out of breath	Quite warm	Jogging
Very hard effort	>84	>93	17–19	Greater increase	Hot	Running fast
Maximal effort	100	100	20	Completely out of breath	Very hot, perspiring heavily	Sprinting all-out

Note: The shaded area identifies intensity levels that are required for health. Adapted from Warburton et al. (2006*b*). HR_{max}, maximal heart rate; HRR, heart rate reserve; RPE, rate of perceived exertion.

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Physical activity (PA) clearance process

The following section was written by the consensus panel that guided the overall revision of the physical activity clearance process. This information is reprinted in each of the systematic review papers so that these reviews can stand alone from the paper describing the overall consensus process (Jamnik et al. 2011).

PA participation is recommended and beneficial for all asymptomatic people and for people with chronic diseases or conditions (Table 1) (Warburton et al. 2006*a*, 2007). However, the PA participation of people with certain chronic disease or conditions or constraints may need to be restricted. The Physical Activity Readiness Questionnaire (PAR-Q) is a screening tool completed by people who plan to undergo a fitness assessment or to become much more physically active, such as when initiating PA participation that is beyond a person's habitual daily activity level or when beginning a structured PA or exercise program. Screening is also recommended when a person is joining a health club, commencing a training program with a fitness professional, or joining a sports team. If a person provides a positive response to any question on the PAR-Q, he or she is directed to consult with his or her physician for clearance to engage in either unrestricted or restricted PA.

The Physical Activity Readiness Medical Evaluation (PARmed-X) is a screening tool developed for use by physicians to assist them in addressing medical concerns regarding PA participation that were identified by the PAR-Q. Recent feedback from PA participants, fitness professionals, and physicians has brought to light the substantial limitations of the utility and effectiveness of PA participation screening by the PAR-Q and PARmed-X. In short, the exercise clearance process is not working as intended and, at times, is a barrier to PA participation for people who may be most in need of increased PA. The aim of this project was for experts in each chronic disease, together with an expert panel, to revise and increase the effectiveness of the PAR-Q and PARmed-X screening process, using an evidence-based consensus approach that adheres to the established Appraisal of Guidelines for Research and Evaluation (AGREE).

An important objective of this project was to provide evidence-based support for the direct role of university-educated and qualified exercise professionals in the exercise clearance process. An example of a qualified exercise professional is the Canadian Society for Exercise Physiology Certified Exercise Physiologist, which is is the highest nationally recognized certification in the health and fitness industry. It recognizes the qualifications of people who possess advanced formal academic preparation and practical experience in health-related and performance-related PA and exercise science fitness applications for both nonclinical and clinical populations.

The AGREE instrument was developed by a group of researchers from 13 countries to provide a systematic framework for assessing the quality and impact of clinical practice guidelines on medical care (AGREE Collaboration 2001, 2003). The AGREE collaboration published the rigorous development process and associated reliability and validity data of the AGREE instrument, based on a large-scale study focused primarily on clinical practice guidelines (AGREE Collaboration 2001, 2003). The AGREE instrument is now a commonly used tool for assessing clinical practice guidelines and other health management guidelines (Lau 2007). The AGREE guidelines were applied in this project to assess the formulation of risk stratification and PA participation clearance recommendations for each of the critical chronic diseases. One of the authors of the this project (J.M.) is an AGREE instrument expert, and she was responsible for evaluating the compliance of the overall process to the AGREE guidelines.

In addition to adhering to the AGREE process, the Level of Evidence (1, randomized control trial; 2, randomized control trial with limitations or observational trials with overwhelming evidence; 3, observational study; 4, anecdotal evidence) supporting each PA participation clearance recommendation and the grade (A, strong; B, intermediate; C, weak) of the PA participation clearance recommendation were assigned by applying the standardized Level and Grade of Evidence detailed in the consensus document (Warburton et al. 2011).

In this series of articles, each chronic disease condition was considered in reference to a continuum of risk, from lower-risk to intermediate (moderate) and higher-risk categories. Particular attention was paid to the short-term (acute) risks of PA and exercise, compared with the long-term (chronic) benefits, on the chronic disease. Physical activity participation may transiently increase the risk acutely, while leading to physiological and psychological adaptations that markedly reduce the long-term risk. Adverse events were considered to be any adverse change in health status or side effect related to PA or exercise participation.

Methods

Eligibility criteria

Eligible studies were peer-reviewed, in English, and origi-

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

nal research articles published before July 2008 (date of submission). Dissertations, theses, and conference proceedings were excluded. Studies employing survey designs where physical activity change could not be identified (e.g., cross-sectional and passive prospective survey designs) were also excluded. This decision was made because the purpose of this review was to appraise the incidence and risk of adverse events resulting from a change in physical activity behaviour, and survey designs cannot assess change. To be considered in this review, adverse events needed to be reported or specifically reported as not occurring. This was based on our inability to determine what the absence of reporting adverse events may mean. Studies with multiple publications from the same dataset were grouped and treated as a single study. Finally, nonclinical populations (e.g., participants with depressive symptoms but not clinical depression) were not considered in the review; all studies had to demonstrate screening of participants with each condition to be included in the review.

Search strategy

This review consisted of systematic database searches and manual cross-referencing of bibliographies. The databases used included PubMed, Medline, Web of Science, PsycInfo, and Sports Discus, which represent databases from multiple disciplines related to health and physical activity. Search terms were various combinations of physical activity, exercise, activity, exercise contraindications, fitness, physical function, physical activity contraindications, physical activity response, adverse events, exercise response, walking, and exercise prescription. These were cross-referenced with combinations of search words for intellectual disability, dementia, and psychological disorders. For intellectual disability, the search terms used were intellectual disability, mental retardation, learning disability, developmental disability, and Down syndrome. For dementia, these terms were dementia, Alzheimer's disease, and cognitive impairment; for psychological disorders, these terms were mental illness, schizophrenia, bipolar disorder, anxiety disorders, panic disorder, depression, depressive disorders, personality disorders, eating disorders, anorexia nervosa, bulimia nervosa, psychiatric disorders, dissociative disorders, and adjustment disorders. The search was completed independently by 2 research assistants (1 at an MA level and 1 at a postdoctoral level), and findings were then collapsed to arrive at eligible studies.

Screening

Citations were screened by 2 reviewers using predefined inclusion criteria. Studies were initially screened on the basis of title and abstract. Relevant abstracts were then selected for a full consideration of the article. Potential studies for adjudication were examined by 2 reviewers independently. It was then determined whether the study met the criteria and would be included in the review. Consensus was reached in 100% of the cases.

Operational definitions of dependent and independent variables

An adverse event was considered to be any physiological or psychological incident, episode, or event that could be attributed to either exercise testing or participation in physical activity. Dementia was defined as a decline in cognitive capacity, measured using the screening procedures in the study. Intellectual disability was defined as a disability characterized by significant limitations in both intellectual functioning and adaptive behaviour (American Association on Mental Retardation 2002), as determined by the selection and (or) recruitment procedures of the included studies. Finally, psychological conditions were defined according to the screening procedures outlined in the studies.

Data abstraction

The research assistants abstracted data using a prespecified 12-item data abstraction form. The abstracted data included authors, sample, study design and setting, population and condition, dependent variables, intervention, intervention length and characteristics, measurement tools, outcomes, and adverse events.

Analysis methods

The results were grouped and appraised on the basis of a priori classification of dementia, intellectual disability, and psychological disorders; however, subthemes or classifications were created on the basis of the availability of studies. Specifically, a subclassification was formed when at least 3 studies could be extracted for a topic (e.g., depression, anxiety) (Gustafson and Rhodes 2006).

Risk of bias was assessed using a checklist tool developed specifically for this review to address adverse events. It was noted by the authors that most studies are not designed to examine naturally occurring adverse events from physical activity; indeed, study quality, ethical issues, and internal validity concerns may limit our understanding of this outcome variable (e.g., careful screening of participants, extremely rigorous safety conditions). The scoring of the tool is similar to that of the Cochrane Collaboration's instrument for assessing risk of bias (Higgins and Green 2008) and that of a checklist created by Downs and Black (1998). The instrument consisted of 5 questions that could be answered with a yes or no format (see Table 2). A score of 5 indicated high quality (i.e., low risk of bias), a score of 3 or 4 indicated moderate quality, and a score of 0 to 2 indicated low quality (i.e., high risk of bias). The 5 questions were: Was the FITT (frequency, intensity, time, type) dose of the physical activity intervention similar to the aims of the PAR-Q in "getting much more active?"; Were the participants representative of the population from which they were recruited (no excessive or careful screening)?; Were the facilities, staff, and location similar to those representative in this population (under normal PAR-Q conditions)?; Was the participant attrition rate of the study considerable?; and Was the sample large enough to make generalizations about normally occurring adverse events in this population? It is important to note that a study considered low quality (high risk of bias) in terms of adverse events may be a high-quality study in terms of its ability to determine a primary outcome (e.g., physical fitness or depression remission). The risk of bias measure in this review should not be extended to any other outcome in the studies reported.

Following the suggestions of the Grade Working Group (Atkins et al. 2004), the overall quality of the studies was reported to describe the general state of research on the topic; this included low-quality studies. This was followed by anal-

RIGHTSLINK

Table 2. Risk of bias in included studies.

	Questions					
Studies	1	2	3	4	5	Total ccore
Schizophrenia						
Knapen et al. (2005)	1	0	0	1	1	3
McDevitt et al. (2005)	1	0	1	1	0	3
Duraiswamy et al. (2007)	0	1	1	0	0	2
Wu et al. (2007)	1	0	0	1	1	3
Anxiety						
Taylor et al. (1987)	0	1	0	0	1	2
Gaffney et al. (1988)	0	1	0	0	0	1
Martinsen et al. (1989*a*)	1	1		1	1	4
Martinsen et al. (1989*b*)	0	0	0	0	1	1
Martinsen et al. (1989*c*)	1	1	0	1	1	4
Stein et al. (1992)	0	0	0	0	0	0
Broocks et al. (1997)	0	0	0	0	1	1
Broocks et al. (1998)	1	0	1	0	0	2
Martinsen et al. (1998)	0	1	0	0	1	2
Meyer et al. (1998)	1	0	1	0	0	2
Schmidt et al. (2000)	0	0	0	0	1	1
Knapen et al. (2005)	1	0	0	1	1	3
Depression						
Martinsen et al. (1989*c*)	1	1	0	1	1	4
Singh et al. (1997)	1	0	0	1	0	2
Blumenthal et al. (1999)	1	0	0	0	1	2
Herman et al. (2002)	1	0	0	1	1	3
Dunn et al. (2005)	1	0	0	1	0	2
Knapen et al. (2005)	1	0	0	1	1	3
McDevitt et al. (2005)	1	0	1	1	0	3
Singh et al. (2005)	1	0	0	1	0	2
Blumenthal et al. (2007)	1	0	1	1	1	4
Knubben et al. (2007)	0	1	0	1	0	2
Eating disorders						
Nudel et al. (1984)	0	1	0	0	0	1
Rigaud et al. (1997)	0	1	0	0	0	1
Sundgot-Borgen et al. (2002)	1	0	1	1	0	3
Tokumura et al. (2003)	1	1	0	1	0	3
Harris et al. (2008)	0	0	0	0	0	0
Dementia						
Lazowski et al. (1999)	1	0	0	0	1	2
Arkin (1999)	1	1	0	1	0	3
Toulotte et al. (2003)	1	1	0	1	0	3
Littbrand et al. (2006)	1	0	0	1	1	3
Rolland et al. (2007)	1	0	0	1	1	3
Intellectual disability						
Bodkin, et al. (2003)	0	0	0	0	0	0
Carmeli et al. (2003)	1	1	0	0	0	2
Cremers et al. (1993)	0	1	1	0	1	3
Halle et al. (1999)	1	1	0	0	0	2
Jones et al. (2006)	0	1	0	0	0	1
Pitetti and Tan (1991)	1	1	0	0	0	2
Pommering et al. (1994)	1	0	0	0	0	1
Rimmer et al. (2004)	1	0	0	0	1	2
Ulrich et al. (2001)	0	1	0	0	1	2
Vashdi et al. (2008)	0	0	0	0	0	0

Note: 1, yes; 0, no. Total score of 0–2, high risk of bias; total score of 3–4, moderate risk of bias; total score of 5, low risk of bias. Question 1, Was the FITT (frequency, intensity, time, type) dose of the physical activity intervention similar to the aims of the PAR-Q in "getting much more active?"; Question 2, Were the participants representative of the population from which they were recruited (no excessive or careful screening)?; Question 3, Were the facilities, staff, and location similar to those representative in this population (under normal PAR-Q conditions)?; Question 4, Was the participant attrition rate of the study considerable(>20%)?; Question 5, Was the sample large enough to make generalizations about normally occurring adverse events in this population ($n > 27$)?

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

yses of the high- and moderate-quality studies, however, to make judgments with some protection from risk of bias (Higgins and Green 2008).

Narrative appraisal and evidence synthesis were subsequently performed using the AGREE processes (Atkins et al. 2004). This approach was chosen over quantitative synthesis (meta-analysis) because of the heterogeneity of the study characteristics, compounded by the overall low number of studies to review. Key factors for consideration in this qualitative appraisal included the overall risk of bias of the studies, (absolute and relative) risk versus benefit from physical activity in each population, and the number of studies available to make a judgment.

Results

Data synthesis

For psychological disorders and dementia, the literature search yielded a total of 92 401 hits. A subsequent title and abstract review yielded 522 potentially relevant records. Of these, 166 abstracts and full text reports were obtained and reviewed. Ten studies for depression (Blumenthal et al. 1999, 2007; Dunn et al. 2005; Herman et al. 2002; Knapen et al. 2005; Knubben et al. 2007; Martinsen et al. 1989*b*; McDevitt et al. 2005; Singh et al. 1997, 2005), 5 studies for dementia (Arkin 1999; Lazowski et al. 1999; Littbrand et al. 2006; Rolland et al. 2007; Toulotte et al. 2003), 4 studies for schizophrenia (Duraiswamy et al. 2007; Knapen et al. 2005; McDevitt et al. 2005; Wu et al. 2007), 12 studies for anxiety (Broocks et al. 1997, 1998; Gaffney et al. 1988; Knapen et al. 2005; Martinsen et al. 1989*a*, 1989*b* 1989*c*, 1998; Meyer et al. 1998; Schmidt et al. 2000; Stein et al. 1992; Taylor et al. 1987), and 5 studies for eating disorders (Harris et al. 2008; Nudel et al. 1984; Rigaud et al. 1997; Sundgot-Borgen et al. 2002; Tokumura et al. 2003) passed the eligibility criteria, and were therefore included (see Fig. 1, based on QUOROM/PRISM guidelines (Moher et al. 1999)).

For intellectual disability, the initial search produced a total of 52 101 citations. Of these citations, 204 were included because they were topic relevant and not duplicates. Of these, 189 were excluded for the following reasons: 49 citations were not empirical studies, 21 did not meet the screening criteria for intellectual disability; 1 represented the same dataset as another published study; and 118 studies did not specifically mention the presence or absence of adverse events. Ultimately, 15 studies involving 467 participants with intellectual disability were included in this review (see Appendix A for details of each study).

Study methodology characteristics

Dementia

Table 3 highlights the characteristics of the 5 studies that examined the effects of physical activity in populations with dementia. Overall, these studies were published within the last 20 years (all studies published after 1990) and are comprised of populations from Western countries (Canada, Europe, United States). Four were randomized control trials, and 1 fit quasi-experimental criteria. The studies, however, feature relatively small sample sizes (range, 14–134). Mean age was 81 years, and approximately two thirds of participants were female. The type of dementia or specific condition varied, but the largest incidence was for AD or undefined dementia. Similarly, the inclusion diagnosis criteria were varied, although most studies used the mini–mental state examination cut scores to identify cognitive impairment. Only 1 study reported no exclusion criteria; all of its participants were based in nursing homes. The other reasons for study exclusion were generally based on participants with exercise contraindications (e.g., endocrine, cardiovascular, terminal illness) or other confounding factors (e.g., schizophrenia, visual impairment). In terms of quality to assess adverse events, 4 of the 5 studies scored in the range of moderate risk of bias; the remaining study was scored as high risk of bias (Lazowski et al. 1999).

Interestingly, 4 of the 5 studies did not employ exercise screening procedures. As one might expect in an older adult population, exercise testing followed submaximal procedures, and tests were not used in 4 of the studies.

The prescribed exercise program characteristics can be found in Table 3. These included a range of resistance, walking, and other movement modalities. Of importance, the intensity of the exercise went unreported in 3 of the 5 studies, making it difficult to interpret any dose–response issues that might have emerged with adverse events. Most of the exercise programs featured durations of less than 6 months, and all were facility supervised.

Psychological disorders

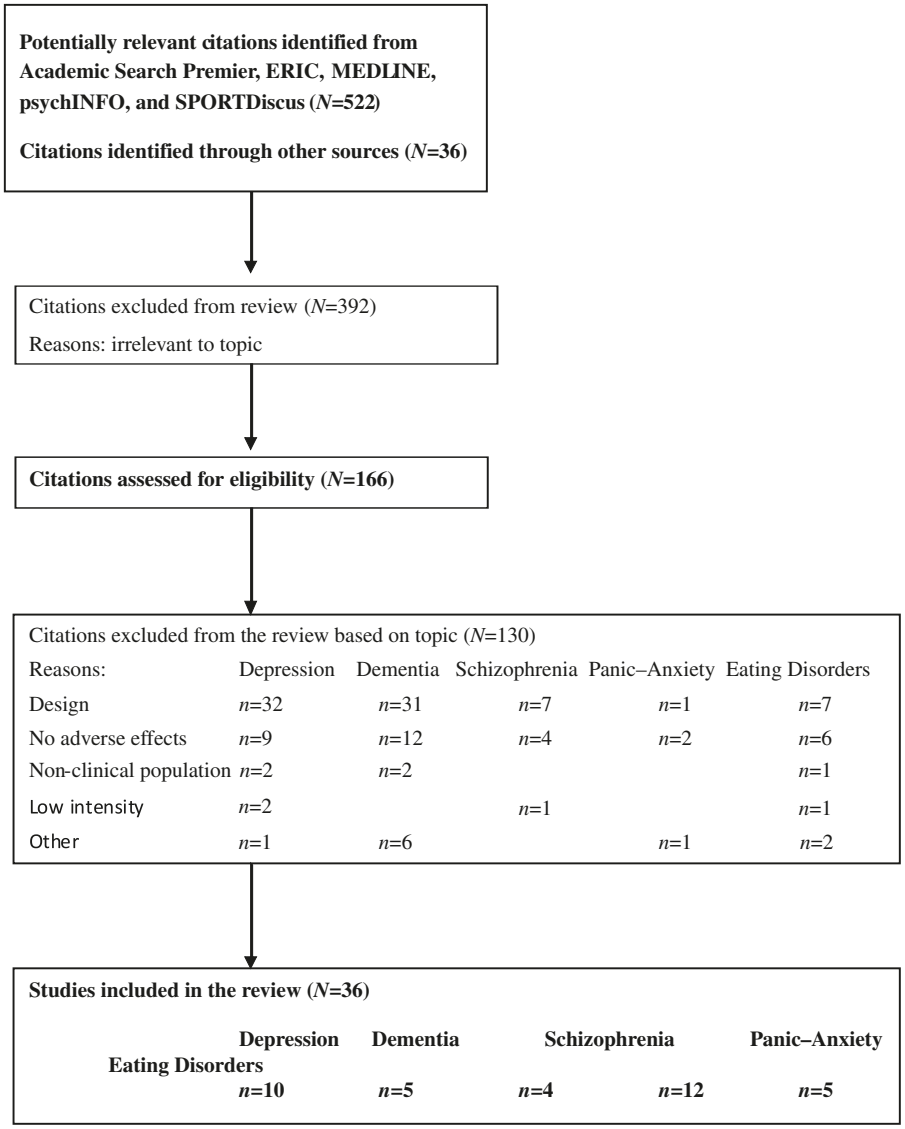
Depression–mood disorders

Table 4 highlights the characteristics of the 10 studies that examined the effects of physical activity in populations with depression. These studies (9 were published after 1990) have some international representation (United States, Europe, Australia). Nine were randomized control trials, and 1 fit quasi-experimental criteria. The studies feature a range of sample sizes (sample size = 90; range, 15–202); 4 studies contained samples larger than 100 participants. Mean age was 52 years, and most studies were focused on middle-aged populations. The type of depression was generally mixed, from mild to severe. In terms of treatment, no studies reported that participants were undergoing pharmacotherapy exclusively, 1 study featured participants receiving psychotherapy, and 1 study indicated that participants were receiving mixed pharmacologic and psychotherapy treatment. Of interest, 4 of the studies indicated no additional treatment, whereas 4 were not clear on psychotherapy but stated that pharmacotherapy was not provided. All studies reported exclusion criteria. The reasons for exclusion were generally related to the severity of depression or specific exercise contraindications, and included the use of antidepressants (50%), specific exercise contraindications (70%), suicidal tendencies (50%), substance abuse (30%), other psychological disorders (30%), and study-specific confounding exclusions such as participation in previous exercise.

Interestingly, 6 of the 10 studies did not employ exercise screening procedures; the rest used physician clearance. Eight of the studies used a variety of maximal or submaximal testing procedures. The prescribed exercise program characteristics included a range of resistance and aerobic activities. The studies employed exercise prescriptions similar to public

RIGHTSLINK

Fig. 1. Results of literature search for dementia and psychological disorders.



health guidelines in terms of frequency, intensity, and duration. Interventions lasted 12 weeks on average, and 8 of the 10 programs were supervised at a facility.

Overall, in terms of study quality to answer adverse event phenomena, 5 of the 10 studies were scored as moderate quality–moderate risk of bias (Blumenthal et al. 2007; Herman et al. 2002; Knapen et al. 2005; Martinsen et al. 1989*b*; McDevitt et al. 2005); the other 5 studies were considered to be low quality–high risk of bias to answer this research question. The ecological validity limitations from the training environment (i.e., programs were highly supervised with trained personnel) and participant characteristics (i.e., most were selected on the basis of low depression and no treatment) were the 2 most prominent risks of bias for adverse events.

Anxiety disorders

Table 5 highlights the characteristics of the 12 studies that examined the effects of physical activity in populations with anxiety disorders. These studies were conducted from 1987 to present, and contain a mix of populations from Europe and the United States. Half were randomized controlled trials; the other half consisted of single-bout exercise experiments conducted to examine responses to exercise. The studies were heterogeneous in terms of sample size, with several featuring small samples and 1 featuring more than 100 participants. All studies, however, featured adults of early middle-age (<50 years). The bulk of the studies featured participants with panic disorder (n = 9); the remaining studies included generalized anxiety or mixed diagnoses. In terms of treatment, no studies reported that participants were undergoing psychotherapy exclusively; 2 studies featured participants receiving pharmacotherapy, and 2 studies indicated that participants were receiving mixed pharmacologic and psychotherapy treatment. The other studies indicated that the participants were receiving no additional treatment or the description was unclear. Three studies reported no exercise exclusion criteria. The reasons for exclusion among the other 9 studies were generally the presence of another psychiatric disorder (50%), specific exercise contraindications (25%), serious mental illness (41%), or substance abuse (25%).

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table 3. Dementia study characteristics (n = 5).

Characteristic	No. of studies
Year of publication	
1980–1989	0 (0%)
1990–1999	2 (40%)
>2000	3 (60%)
Country of publication	
United States	1 (42.9%)
Canada	1 (7.1%)
France	2 (21.4%)
Sweden	1 (7.1%)
No. of subjects	
Total	427
Median (min–max)	68 (14–134)
0–50	2 (40%)
51–100	1 (20%)
>101	2 (40%)
Age (y)	
Mean (estimated)	80.92
75–80	1 (20%)
81–85	4 (80%)
>86	0 (0%)
Not stated	0 (0%)
Gender (% of total participants)	
Male	42 (9%)
Female	160 (37%)
No. of subjects undifferentiated	225 (52%)
Type of dementia	
Alzheimer's disease	2 (40%)
Multiple infarct	0 (0%)
Mixed (vascular, Parkinson's, etc.)	0 (0%)
Demented and nondemented subjects	1 (20%)
Undefined dementia	2 (40%)
Dementia diagnosis for inclusion*	
DSM-MD III or IV	0 (0%)
MMSE	1 (20%)
NINCDS-ADRDA	1 (20%)
Physician-confirmed diagnosis	2 (40%)
Not stated	1 (20%)
Study design	
Randomized controlled trial	4 (80%)
Cross-sectional	0 (0%)
Prospective, interventional	1 (20%)
Prospective, noninterventional	0 (0%)
Reasons for patient exclusion*	
Vascular dementia–Parkinson's disease	1 (20%)
Contraindication to exercise (endocrine, neurological, orthopaedic disorder)	1 (20%)
Cardiopulmonary or cardiovascular disease–disorder	1 (20%)
Primary psychiatric disorder (e.g., schizophrenia, MDD)	0 (0%)
Mental retardation	0 (0%)
Malnutrition	0 (0%)
Malignancy	0 (0%)
Endocrine disease	0 (0%)
Terminal illness	1 (20%)
Surgery in the coming year	0 (0%)
Unable to ambulate or stand up without assistance	2 (40%)
Blind	1 (20%)
MMSE < 10	1 (20%)
<65 y old	1 (20%)
Only listed inclusion criteria	0 (0%)
No exclusion criteria listed	2 (40%)
Study prescreening exercise procedures*	
Physician	1 (20%)
Care staff	0 (0%)
Negative exercise test	0 (0%)
Prescreening exercise tool (PAR-Q or PARmed-X)	0 (0%)
Not stated	4 (80%)
Type of exercise test	
Maximal, cardiopulmonary exercise test	0 (0%)
Maximal, without expired gas exchange assessment	0 (0%)
Submaximal, age-predicted heart rate test	0 (0%)
Sumaximal, walk test	1 (20%)
Submaximal, other	0 (0%)
Not stated	3 (60%)
Exercise test modality*	
Cycle ergometer	0 (0%)
Treadmill	0 (0%)
Walk test	3 (60%)
Timed-Up-and-Go	3 (60%)
Sit to stand	0 (0%)
Other	0 (0%)
Not stated	0 (0%)
Exercise test monitoring*	
Physician-monitored	0 (0%)
ECG	0 (0%)
Blood pressure	0 (0%)
Continuous heart rate	0 (0%)
Rate of perceived exertion	0 (0%)
Not stated	4 (80%)
Exercise training modality	
Resistance training (seated or standing)	3
Body movement (with or without music)	0
Functional exercise	1
Walking	0
Adapted activities	0
Combined (aerobic and resistance training)	1
Exercise prescription frequency (sessions per wk)	
Median (minimum–maximum)	2 (2–3)
0–2	4 (80%)
3	1 (20%)
>3	0 (0%)
Exercise prescription duration (min per session) excluding warm-up	
Median (minimum–maximum)	45 (20–60)
0–30	1 (20%)
31–45	3 (60%)
>46	1 (7.1%)
Not stated	0 (0%)
Exercise prescription intensity (as stated by the authors)	
Low	0 (0%)
Moderate	1 (20%)

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table 3 (*concluded*).

Characteristic	No. of studies
High	1 (20%)
Mixed (low, moderate, high intensity)	0 (0%)
Not stated	3 (60%)
Exercise prescription intervention length (wk)	
Median (minimum–maximum)	16 (13–52)
0–12	1 (20%)
13–23	2 (40%)
>24	2 (40%)
Exercise training safety monitoring*	
Continuous heart rate	0 (0%)
Blood pressure	0 (0%)
Rate of perceived exertion	0 (0%)
Not stated	5 (100%)
Exercise intervention setting	
Supervised	4 (80%)
Unsupervised (home-based)	0 (0%)
Not stated	1 (20%)

Note: DSM-MD, Diagnostic and Statistical Manual of Mental Disorders; ECG, electrocardiograph; MDD, major depressive disorder; MMSE, mini–mental state examination; NINCDS-ADRDA, National Institute of Neurological and Communicative Disorders and Stroke-Alzheimer's Disease and Related Disorders Association; PAR-Q, Physical Activity Readiness Questionnaire; PARmed-X, Physical Activity Readiness Medical Evaluation.

*Studies could report more than 1 criterion.

Interestingly, 8 of the 12 studies did not employ exercise screening procedures; the rest used physician clearance. Most of the studies (10 of 12) used submaximal or maximal exercise testing procedures (Table 6). The prescribed exercise program characteristics for the 6 intervention studies included a range of resistance and aerobic activities. The intensity of the exercise went unreported in 3 of the studies, but the remaining 3 studies reported moderate- to high-intensity activities, reflecting current guidelines. Similarly, most of the exercise programs featured frequencies of 3 times per week at durations of less than an hour. Intervention length and setting were heterogeneous (10 weeks; range, 8–16 weeks).

In terms of study quality assessment, 6 of the studies featured single-bout exercise, and thus do not lend themselves to understanding adverse events related to adherence to a change in physical activity behaviour. Other concerns included excessive screening, questionable facility-based exercise being generalized to the free-living population, and sample size concerns when generalizing to the populace with anxiety disorders. Overall, 3 (Knapen et al. 2005; Martinsen et al. 1989*a*, 1998) of the 12 studies scored in the range of modest risk of bias, and no study was considered to have a low risk of bias.

Eating disorders

Only 5 studies identified focused on physical activity and eating disorders (Table 7). These spanned several countries (United States, Japan, France, Norway), Four of the 5 focused on anorexia nervosa, and a single study included bulimia nervosa. The studies featured young participants (mean age, 23 years) who were mostly female, who received no explicit treatment for their condition. Four of the studies fea-

Table 4. Depression study characteristics (n = 10).

Characteristic	No. of Studies
Year of publication	
1980–1989	1 (10%)
1990–1999	2 (20%)
>2000	7 (70%)
Country of publication	
United States	6 (60%)
Norway	1 (10%)
Australia	1 (10%)
Belgium	1 (10%)
Germany	1 (10%)
No. of subjects	
Median (minimum–maximum)	90 (15–202)
0–50	3 (30%)
51–100	3 (30%)
>101	4 (40%)
Age (y)	
Mean (estimated)	51.6
21–40	0 (0%)
41–60	8 (80%)
>61	2 (20%)
Not stated–unclear	0 (0%)
Gender	
Male	278 (26%)
Female	566 (53%)
Undetermined	217 (21%)
Type of depression	
Mixed levels of MDD (mild to severe depression)	6 (60%)
Serious mental illness (MDD with other disorders)	3 (30%)
Unipolar depression	1 (10%)
Bipolar disorder (manic depression)	0 (0%)
Depression treatment	
Psychotherapy	1 (10%)
Pharmatherapy	0 (0%)
Mixed	1 (10%)
Unclear	4 (40%)
None	4 (40%)
Study design	
Randomized controlled trial	9 (90%)
Cross-sectional	0 (0%)
Prospective, interventional	1 (10%)
Prospective, noninterventional	0 (0%)
Reasons for patient exclusion*	
Special medical contraindication to exercise	7 (70%)
Participation in regular exercise (similar to treatment)	2 (20%)
Current use–history of antidepressants/psychotropics	5 (50%)
Ongoing or past psychotherapy	3 (30%)
Current–history of substance abuse (alcohol–drugs)	3 (30%)
Presence of another primary psychiatric disorder	3 (30%)
Suicidal tendencies	5 (50%)
Dementia–cognitive impairment	2 (20%)
Cardiopulmonary–cardiovascular disease	2 (20%)
Neurological disorder	1 (10%)

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table 4 (*continued*).

Characteristic	No. of Studies
Orthopaedic disorder	1 (10%)
Uncontrolled diabetes	1 (10%)
Planned or current pregnancy	1 (10%)
Only inclusion criteria listed	0 (0%)
No exclusion or inclusion criteria listed	0 (0%)
Study prescreening exercise procedures*	
Physician	4 (40%)
Negative exercise test	0 (0%)
Prescreening exercise tool (PAR-Q or PARmed-X)	0 (0%)
Not stated	6 (60%)
Type of exercise test	
Maximal, cardiopulmonary exercise test	4 (40%)
Submaximal, age-predicted heart rate test	0 (0%)
Sumaximal, 6–12-min walk test	0 (0%)
Submaximal, other	2 (20%)
1RM	2 (20%)
Not stated	1 (10%)
Other	1 (10%)
Exercise test modality	
Cycle ergometer	1 (10%)
Treadmill	5 (50%)
Walk or stand test	0 (0%)
Weight machine	2 (20%)
Other	1 (10%)
Not stated	1 (10%)
Exercise test monitoring*	
Physician-monitored	0 (0%)
ECG	3 (30%)
Blood pressure	0 (0%)
Continuous heart rate	1 (10%)
Rate of perceived exertion	1 (10%)
Not stated	6 (60%)
Exercise training modality	
Combined aerobic plus resistance training	0
Dance–movement	0
Yoga	0
Walking–jogging (indoor or outdoor)	6
Martial arts	0
Resistance training	3
2 exercises groups (various modalities)	1
Health promotion session	0
Exercise prescription frequency, sessions per wk	
Median (minimum–maximum)	3 (3–3)
0–2	0 (0%)
3	9 (90%)
>3	0 (0%)
Not stated	1 (10%)
Exercise prescription duration (min per session) excluding warm-up	
Median (minimum–maximum)	30 (30–60)
0–30	5 (50%)
31–45	1 (10%)
>46	2 (20%)
Not stated	2 (20%)
Exercise prescription intensity (% heart rate)	
<50%	1 (10%)
50%–70%	1 (10%)
>70%	5 (50%)
2 groups of varying intensity (e.g., low and high)	4 (16.7%)
80% 1RM	2 (20%)
Not stated/unclear	0 (0%)
Exercise prescription intervention length (wk)	
Median (min–max)	12 (10 days–16 wk)
0–11	4 (40%)
12–23	6 (60%)
>24	0 (0%)
Not stated	0 (0%)
Exercise training safety monitoring*	
Continuous heart rate	5 (50%)
Blood pressure	0 (0%)
Rate of perceived exertion	6 (60%)
Not stated	2 (20%)
Exercise intervention setting	
Supervised	8 (80%)
Unsupervised (home-based)	0 (0%)
Mixed setting (supervised and unsupervised)	0 (0%)
Not stated	2 (20%)

Note: RM, repetition maximum.
*Studies could report more than 1 criterion.

tured no exercise screening, and 1 study used physician clearance.

Of the 2 studies that included an exercise training intervention, one was stationary cycling and the other was a mix of activities. Both appeared to be within public health guideline intensities, frequency, and duration; the lengths of the programs were 16 and 40 weeks.

Three studies were designed to examine the effects of a single bout of exercise and do not lend themselves to identifying adverse events from sustained activity. Overall, 2 of the studies met the scores for a modest risk of bias in assessing adverse events (Sundgot-Borgen et al. 2002; Tokumura et al. 2003); the other 3 studies scored a high risk of bias.

Schizophrenia–psychotic disorders

Table 6 highlights the characteristics of the 4 studies that examined the effects of physical activity in populations with psychotic disorders. These studies are relatively recent (all published after 2000), and represent participants from the United States ($n = 1$), Europe ($n = 1$), and Asia ($n = 2$). Three of the 4 studies were randomized controlled trials; the other was a prospective single-group trial. The studies were comprised of medium-sized samples, with 1 exception (McDevitt et al. 2005). Most featured young or early middle-aged adults, and the gender representation was roughly equal. Three of the studies featured schizophrenia patients exclusively; the remaining study included participants with schizophrenia and other psychiatric disorders. In terms of treatment, all studies reported that participants were receiving pharmacotherapy. All but 1 study (Duraiswamy et al. 2007) reported several exclusion criteria. The reasons for exclusion in these studies were generally based on health contraindications for exercise.

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table 5. Effects of physical activity in populations with anxiety disorders.

(*a*) Anxiety study (*n* = 12).	
Characteristic	No. of studies
Year of publication	
1980–1989	5 (41%)
1990–1999	5 (41%)
>2000	2 (16%)
Country of publication	
United States	4 (33%)
Norway	4 (33%)
Germany	3 (25%)
Belgium	1 (8%)
No. of subjects	
Median (minimum–maximum)	50 (20–199)
0–50	6 (50%)
51–100	5 (41%)
>101	1 (8%)
Age (y)	
Mean (estimated)	33.4
0–20	0 (0%)
21–50	12 (100%)
>51	0 (0%)
Not stated	0 (0%)
Gender (*n* = 802)	
Male	285 (35%)
Female	454 (56%)
Gender ratio not stated	60 (7%)
Disorder	
Panic disorder (with or without agoraphobia)	9 (75%)
Anxiety disorder	1 (8%)
MDD (comorbidity of anxiety disorder)	1 (8%)
Mixed disorders (anxiety, mood, personality)	1 (8%)
Treatment prior to the study	
Psychotherapy	0 (0%)
Pharmatherapy	2 (17%)
Mixed (psycho and pharma)	2 (17%)
Unclear	7 (58%)
None	1(8%)
Study design	
Randomized controlled trial	6 (50%)
Single-bout experimental	6 (50%)
Prospective, interventional	0 (0%)
Prospective, noninterventional	0 (0%)
Reasons for patient exclusion*	
Medical contraindication to exercise	3 (25%)
Pregnancy–lactation	4 (33%)
Participation in regular exercise	3 (25%)
Substantial medical illness	5 (41%)
Presence of another primary psychiatric disorder	6 (50%)
Anorexia or bulimia nervosa	3 (25%)
Substance abuse–drug dependency	3 (25%)
Current involvement in psychotherapy	0 (0%)
Current use of psychotropic medication	0 (0%)
Not exclusion criteria	3 (25%)
Study prescreening exercise procedures*	
Physician	4 (33%)
Negative exercise test	0 (0%)
Prescreening exercise tool (PAR-Q or PARmed-X)	0 (0%)
Not stated	8 (66%)
Type of exercise test	
Maximal, cardiopulmonary exercise test	3 (25%)
Maximal, without expired gas exchange assessment	0 (0%)
Submaximal, age-predicted heart rate test	0 (0%)
Sumaximal, 6- to 12-min walk test	0 (0%)
Submaximal, other	7 (58%)
Not stated	2 (16%)
Exercise test modality	
Cycle ergometer	11 (91%)
Treadmill	0 (0%)
Walk test	0 (0%)
Other	0 (0%)
Not stated	1 (8%)
Exercise test monitoring*	
Physician-monitored	0 (0%)
ECG	3 (25%)
Blood pressure	0 (0%)
Continuous heart rate	5 (41%)
Rate of perceived exertion	3 (25%)
Not stated	5 (41%)

Table 5 (*continued*).

(*b*) Intervention study (*n* = 6 of 12).	
Characteristics	No. of studies
Exercise training modality	
Combined aerobic plus resistance training	0 (0%)
Jogging (indoor–outdoor)	3 (50%)
2 exercise groups use different training modalities	2 (33%)
Lifestyle education sessions	0 (0%)
Not stated	1 (16%)
Exercise prescription frequency (sessions per wk)	
Mean	3
0–2	0 (0%)
3	5 (83%)
>3	0 (0%)
Not stated	1 (16)
Exercise prescription duration (min per session) excluding warm-up	
Median (minimum–maximum)	45 (30–60)
0–30	1 (16%)
31–45	0 (0%)
>46	2 (33%)
Not stated	3 (50%)
Intensity (% heart rate)	
<50%	0 (0%)
50%–70%	3 (50%)
>70%	0 (0%)
2 exercise groups of varying intensities	0 (0%)
Not stated–unclear	3 (50%)
Intervention length (wk)	
Median (minimum–maximum)	10 (8–16)
0–12	5 (83%)
12–23	1 (16%)
>24	0 (0%)

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table 5 (*concluded*).

(*b*) **Intervention study (*n* = 6 of 12).**	
Characteristics	No. of studies
Exercise training safety monitoring*	
Continuous heart rate	1 (16%)
Blood pressure	0 (0%)
Rate of perceived exertion	0 (0%)
Not stated	5 (83%)
Exercise intervention setting	
Supervised	1 (16%)
Unsupervised (home-based)	0 (0%)
Mixed setting (supervised and unsupervised)	2 (33%)
Not stated	3 (50%)

*Studies could report more than 1 criterion.

Three of the 4 studies did not employ exercise screening procedures; 1 study utilized physician clearance. In addition, these 3 studies did not report exercise testing procedures. The prescribed exercise program characteristics included a range of resistance and aerobic activities. The intensity of the exercise went unreported in half of the studies, but the remaining 2 studies reported moderate- to high-intensity activities, reflecting current guidelines (Warburton et al. 2007). Similarly, most of the exercise programs featured frequencies of 3 times per week at durations of less than an hour. Intervention length and setting were extremely heterogeneous (14 weeks; range, 3–24 weeks).

In terms of study quality (Table 2), 3 of the 4 studies showed a score in the moderate range, and 1 study suggested a high risk of bias (Duraiswamy et al. 2007).

Intellectual disability

Fifteen studies, involving 467 participants with intellectual disability, were identified (Table 8). Thirteen percent of the studies were published prior to 1990, 33% were published during the 1990s, and the remaining 53% were published since 2000. The majority of the studies were conducted in the United States (60%), 27% were conducted in the United Kingdom or Europe, and 13% were conducted in Israel. The average number of participants in these studies was 31 (SD, 31.5; range, 1–135), with 87% involving fewer than 50 participants. The majority of participants were male (52%); however, gender was not specified in 2 studies (or 12% of participants). The degree of intellectual disability was not reported for 47% of participants. When reported, mild or moderate intellectual disability was the most common categorization (34%); severe or profound intellectual disability was less prevalent (5%). A proportion of the participants were undifferentiated in terms of degree of intellectual disability across a spectrum of moderate to severe intellectual disability (7%) or mild to severe intellectual disability (3%). Seven studies only recruited people with Down syndrome (68%); 2 studies included individuals with intellectual disability, but specifically excluded participants with Down syndrome; 1 study (4%) included individuals with Down syndrome and other causes of intellectual disability; and in the remaining 5 studies (19%), etiology was not reported.

The following prescreening procedures were reported among the 15 studies: physician clearance alone (53%); physician clearance with prescreening tool, such as the

Table 6. Schizophrenia study (*n* = 4).

Characteristics	No. of studies
Year of publication	
1980–1989	0 (0%)
1990–1999	0 (0%)
>2000	4 (100%)
Country of publication	
United States	1 (25%)
Europe	1 (25%)
Asia	2 (50%)
No. of subjects	
Median (minimum–maximum)	57 (15–199)
0–50	1 (25%)
51–100	2 (50%)
>101	1 (25%)
Age (y)	
Mean (estimated)	35.1
0–20	0 (0%)
21–50	3 (75%)
>51	0 (0%)
Not stated	1 (25%)
Gender (% of total participants)	
Male	135 (41%)
Female	178 (54%)
Undetermined	15 (4%)
Disorder	
Schizophrenia	2 (50%)
Schizophrenia and schizoaffective disorder	1 (25%)
Schizophrenia and other primary psychiatric disorders	0 (0%)
Serious mental illness (psychotic/mood/personality)	1 (25%)
Treatment prior to the study	
Psychotherapy	0 (0%)
Pharmatherapy	2 (50%)
Mixed (psycho and pharma)	2 (50%)
Unclear	(0%)
None	(0%)
Study design	
Randomized controlled trial	3 (75%)
Cross sectional	0 (0%)
Prospective, interventional	1 (25%)
Prospective, noninterventional	0 (0%)
Reasons for patient exclusion*	
Pulmonary or cardiovascular disease–disorder	3 (75%)
Contraindications to exercise (e.g., neuromuscular, endocrine, orthopaedic disorder)	3 (75%)
Type 1 diabetes	1 (25%)
Suffering from psychosis	1 (25%)
Mental retardation	2 (50%)
Substance abuse	1 (25%)
Use of beta-blockers, diltiazem, or verapamil	0 (0%)
Unable to complete assessment battery	0 (0%)
Not exclusion criteria listed	0 (0%)
Study prescreening exercise procedures*	
Physician	1 (25%)
Negative exercise test	0 (0%)
Prescreening exercise tool (PAR-Q or PARmed-X)	0 (0%)
Not stated	3 (75%)

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table 6 (*continued*).

Characteristics	No. of studies
Type of exercise test	
Maximal, cardiopulmonary exercise test	1 (25%)
Maximal, without expired gas exchange assessment	0 (0%)
Submaximal, age-predicted heart rate test	0 (0%)
Sumaximal, 6- to 12-min walk test	0 (0%)
Submaximal, other	0 (0%)
Not stated–none	3 (25%)
Exercise test modality	
Cycle ergometer	1 (25%)
Treadmill	0 (0%)
Walk test	0 (0%)
Step test	0 (0%)
Not stated–none	0 (0%)
Exercise test monitoring*	
Physician-monitored	0 (0%)
ECG	0 (0%)
Blood pressure	0 (0%)
Continuous heart rate	1 (25%)
Rate of perceived exertion	1 (25%)
Not stated–none	2 (50%)
Exercise training modality	
Combined aerobic plus resistance training	0 (0%)
Resistance training	0 (0%)
Walking (inside–outside)	3 (75%)
Horseback riding	0 (0%)
2 exercise groups using different training modalities	1 (25%)
Health promotion sessions	0 (0%)
Exercise prescription frequency (sessions per wk)	
Median (minimum–maximum)	3 (3–5)
0–2	0 (0%)
3	3 (75%)
>3	1 (25%)
Not stated	0 (0%)
Exercise prescription duration (min per session) excluding warm-up	
Median (minimum–maximum)	30 (20–60)
0–30	2 (50%)
31–45	0 (0%)
>46	1 (25%)
Not stated	1 (25%)
Exercise prescription intensity (% heart rate)	
<50%	0 (0%)
50%–70%	1 (25%)
>70%	1 (25%)
Not stated or unclear	2 (50%)
Exercise prescription intervention length (wk)	
Median (minimum–maximum)	14 (3–24)
0–12	2 (50%)
13–23	1 (25%)
>24	1 (25%)
Exercise training safety monitoring*	
Continuous heart rate	1 (25%)
Blood pressure	0 (0%)
Rate of perceived exertion	1 (25%)
Not stated	3 (75%)
Exercise intervention setting	
Supervised	2 (50%)
Unsupervised (home-based)	0 (0%)
Mixed setting (supervised and unsupervised)	0 (0%)
Not stated	2 (50%)

Table 6 (*concluded*).

*Studies could reportmore than 1 criterion.

PARQ (7%); and physician clearance with negative exercise test (13%). Study prescreening procedures were not reported for 40% of all studies ($n = 6$). Of the studies that included maximal or submaximal cardiopulmonary exercise tests, 75% reported their prescreening protocols, and 71% of these protocols involved physician clearance. The most frequently cited exclusion criteria for participants were medical contraindications to exercise (47%), motor or ambulatory impairment (27%), musculoskeletal or orthopaedic conditions (13%), abnormal electrocardiograph or echocardiogram (13%), or congenital heart disease (13%). Eleven other conditions were specifically screened for; however, each was only reported in 1 study. Very few studies reported how many participants were screened out on the basis of the study's inclusion and exclusion criteria.

Familiarization to the protocol was reported in 8 studies (53%). The number of familiarization sessions ranged from 1 to 3. Eighty-six percent of the studies that included maximal or submaximal cardiopulmonary exercise tests reported familiarization protocols; a number of these protocols have been published elsewhere (Fernhall and Tymeson 1987; Pitetti et al. 2000).

Safety monitoring was reported for all studies involving maximal and submaximal cardiopulmonary exercise tests ($n = 9$). Heart rate was monitored in each of these studies (electrocardiograph monitoring, 89%) and blood pressure was monitored in 44% of studies. Physician monitoring of testing was reported in only 1 study. Table 9 illustrates the fact that exercise interventions typically occurred in fully supervised settings (70%), but in 20% of the studies ($n = 2$), settings had both supervised and unsupervised components. These 2 studies were infant early intervention programs that included treadmill walking (Bodkin et al. 2003; Ulrich et al. 2001), were facilitated by therapists and (or) staff, and included an at-home component conducted by parents. Staff supervision of exercise training for safety (i.e., correct technique and appropriate behaviour) was reported in majority of studies (70%), and heart rate was monitored in 60% of the training studies. All of the studies that specifically focused on cardiovascular outcomes with specified training intensities monitored heart rate. The supervision ratio was not stated in 50% of the intervention studies. When reported, the ratios were 1:1 in 4 studies and 1:3 in 1 study.

Adverse events

Dementia

Adverse events during exercise testing and training are reported in Table 10. Overall, there were 184 events from a total of 427 participants, for an average of 43% of events per sample. No events were documented during exercise testing.

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table 7. Studies on physical activity and eating disorders.

(*a*) Eating disorder study (*n* = 5).	
Characteristics	No. of studies
Year of publication	
1980–1989	1 (20%)
1990–1999	1 (20%)
>2000	3 (60%)
Country of publication	
United States	2 (40%)
France	1 (20%)
Norway	1 (20%)
Japan	1 (20%)
No. of subjects	
Median (minimum–maximum)	30 (16–64)
0–50	4 (80%)
51–100	1 (20%)
>101	0 (0%)
Age (y)	
Mean (estimated)	23.3
0–20	2 (40%)
21–50	3 (60%)
>51	0 (0%)
Not stated	0 (0%)
Gender (% of total participants)	
Male	6 (3%)
Female	75 (46%)
Undetermined	81 (50%)
Disorder	
Anorexia nervosa	4 (80%)
Bulimia nervosa	1 (20%)
Treatment prior to the study	
Psychotherapy	0 (0%)
Pharmatherapy	0 (0%)
Mixed (psycho and pharma)	0 (0%)
Unclear	2(0%)
None	3 (0%)
Study design	
Randomized controlled trial	1 (20%)
Single exercise bout intervention	3 (60%)
Prospective, interventional	1 (20%)
Prospective, noninterventional	0 (0%)
Reasons for patient exclusion*	
Treatment for eating disorders within last 6 months	2 (40%)
Use of medication	1 (20%)
Smoke or use alcohol	1 (20%)
Concurrent psychiatric disorders	1 (20%)
Pregnant	1 (20%)
BMI >19 $kg \cdot m^{-2}$	1 (20%)
No exclusion criteria listed	3 (60%)
Study prescreening exercise procedures*	
Physician	1 (20%)
Negative exercise test	0 (0%)
Prescreening exercise tool (PAR-Q or PARmed-X)	0 (0%)
Not stated	4 (80%)
Type of exercise test	
Maximal, cardiopulmonary exercise test	2 (40%)
Maximal, without expired gas exchange assessment	0 (0%)
Submaximal, age-predicted heart rate test	0 (0%)
Sumaximal, 6- to 12-min walk test	1 (20%)
Submaximal, other	1 (20%)
Not stated–none	1 (20%)
Exercise test modality	
Cycle ergometer	2 (40%)
Treadmill	1 (20%)
Walk test	1 (20%)
Step test	0 (0%)
Not stated–none	1 (20%)
Exercise test monitoring*	
Physician-monitored	0 (0%)
ECG	2 (40%)
Blood pressure	0 (0%)
Continuous heart rate	0 (0%)
Rate of perceived exertion	0 (0%)
Not stated–none	3 (60%)

Table 7 (*continued*).

(*b*) Exercise intervention study (*n* = 2 of 5).	
Characteristic	No. of studies
Exercise training modality	
Combined aerobic plus nonaerobic activities	1 (50%)
Resistance training	0 (0%)
Stationary cycling	1 (50%)
2 exercise groups using different training modalities	0 (0%)
Health promotion sessions	0 (0%)
Exercise prescription frequency (sessions per wk)	
Median (minimum–maximum)	4 (3–5)
0–2	0 (0%)
3	1 (50%)
>3	1 (50%)
Not stated	0 (0%)
Exercise prescription duration (min per session) excluding warm-up	
Median (min–max)	(30–35)
0–30	1 (50%)
31–45	1 (50%)
>46	0 (0%)
Not stated	0 (0%)
Exercise prescription intensity (% heart rate)	
<50%	0 (0%)
50%–70%	1 (50%)
>70%	0 (0%)
Not stated or unclear	1 (50%)
Exercise prescription intervention length (wk)	
Median (minimum–maximum)	28 (16–40)
0–12	0 (0%)
13–23	1 (50%)
>24	1 (50%)
Exercise training safety monitoring*	
Continuous heart rate	1 (25%)
Blood pressure	0 (0%)
Rate of perceived exertion	1 (25%)
Not stated	3 (75%)

RIGHTSLINK

Table 7 (*concluded*).

(*b*) Exercise intervention study ($n = 2$ of 5).	
Characteristic	No. of studies
Exercise intervention setting	
Supervised	0 (0%)
Unsupervised (home-based)	1 (50%)
Mixed setting (supervised and unsupervised)	1 (50%)
Not stated	0 (0%)

Note: BMI, body mass index.
*Studies could report more than 1 criterion.

Further, 3 of the 5 studies reported an absence of adverse events (Arkin 1999; Lazowski et al. 1999; Toulotte et al. 2003). Overall, the studies reporting adverse events indicated no severe implications and a rate per session of 5% or lower (Littbrand et al. 2006; Rolland et al. 2007). A comparison indicated that the studies are similar in characteristics, although the 2 adverse event studies contained larger samples. Musculoskeletal soreness and reported injury comprise the majority of events reported, followed by dizziness and (or) breathlessness. A small number of falls (<3%) were reported among the events. The adverse events were not attributed to dementia specifically; rather, these events were considered to be the consequence of standard exercise, aging, or comorbidities. In terms of appraisal of the studies using the AGREE framework, their qualities showed a modest risk of bias for addressing adverse events, but they are relatively small in number; the Level of Evidence was therefore deemed to be 3. The number of adverse events, however, suggests that some risk–benefit issues are present. These do not appear to be severe, but warrant a score of B. Thus, it appears that the Grade of Evidence for adverse events among demented populations is currently 3B.

Grade for screening and physical activity clearance among populations with dementia is 3B.

Psychological conditions

Depression

Adverse events during exercise testing and training are reported in Table 11. Overall, there were 33 events from a total of 1061 participants, for an average of 3% of events per sample. Only 1 study documented adverse events during exercise testing. The event reported was leg cramping, but no incidence was included in the report and it does not appear to be specifically linked to depression. For adverse events during the exercise program, 2 studies noted no events and another 2 did not report documentation of events. Thus, 6 studies are available to discern the prevalence and quality of adverse events. The most frequent events are from either physical ailments (musculoskeletal injury, pain) or coinciding pharmacotherapy (loose stool), but 2 participants had worsening depressive symptoms and 1 participant had increased suicidality. A comparison of these studies indicated no specific differences in characteristics. Two studies by Singh et al. (1997, 2005) specifically tested the occurrence of adverse events with exercise and control conditions. No significant differences were noted. In terms of appraisal of these studies using the AGREE framework, the quality of the studies reflect Level 3, and the adverse events in terms of benefit to risk suggest a grade of A. This 3A appraisal is made by considering the overall modest quality of the studies in answering this question, mixed with the very low adverse events and compelling evidence for exercise as an antidepressant influence (Warburton et al. 2007).

Grade for screening and physical activity clearance among populations with depression is 3A.

Anxiety

Adverse events during exercise testing and training are reported in Table 12. Overall, there were 15 events from a total of 802 participants, for an average of 1% of events per sample. Four of 6 of the single-bout studies documented adverse events; 5 of these were panic studies in which the authors suggested the rate of adverse events was within the normal range of attacks in this populace. Thus, the reponse to exercise was not considered severe. Among the 6 longitudinal training studies, only 1 participant had a panic attack, which is below normal values and supports the anxiolytic effect of physical activity (Warburton et al. 2007). Importantly, among the 3 studies that scored only a modest risk of bias to assess adverse events, no adverse events that could be linked to anxiety were identified. In terms of appraisal of these studies using the AGREE framework, the collection of evidence is relatively sparse, but seems to be of low risk; a score of Level 3A has been provided.

Grade for screening and physical activity clearance among populations with anxiety is 3A.

Eating disorders

Table 13 highlights the 5 studies that evaluated adverse events with eating disorders. Overall, only 7 incidents were reported (4%); these included arrhythmia and injury. Further, only 1 adverse event, an injury, was reported in the 2 studies deemed to be of modest risk of bias. This complement of studies is limited at present and is not well suited to answer the research question, so any consideration of adverse events is probably premature. Still, no particular concerns were noted among the 162 participants. In terms of AGREE scoring, Level 3B has been provided.

Grade for screening and physical activity clearance among populations with eating disorders is 3B.

Schizophrenia–psychotic disorders

Adverse events during exercise testing and training are reported in Table 9. Overall, 3 of 4 studies reported no adverse events as a result of the exercise intervention (Duraiswamy et al. 2007; Knapen et al. 2005; Wu et al. 2007). Only 1 study mentioned adverse events in both the exercise testing and intervention (McDevitt et al. 2005). The authors of that study reported complaints of leg cramping and pain among participants during exercise testing, and observed tendencies for the participants to feel self-conscious in public during the walking program. No actual incidents or formal documentation of either event was included. A comparison of this study with the other studies shows comparable findings in terms of quality, design, and intervention. In terms of appraisal of these studies using the AGREE framework, the 4 studies represent a small number from which to draw conclusions and a moderate risk of bias to assess adverse events (Level 3). Nevertheless, reported adverse events appear negligible in

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table 8. Intellectual disability study (n = 15).

Characteristics	No. of studies	No. of subjects
Year of publication		
1980–1989	2 (13.3%)	
1990–1999	5 (33.3%)	
>2000	8 (53.3%)	
Country of publication		
United States	8 (53.3%)	
Canada	0 (0%)	
United Kingdom–Europe	4 (26.7%)	
Other	3 (20.0%)	
No. of subjects		
Total no.		467
Mean±SD		31.1±31.5 (range 1–135)
0–20	7 (46.7%)	
21–50	6 (40.0%)	
>50	2 (13.3%)	
Age (y)*		
Mean		23.1±16.3
≤18	8 (42.1%)	
19–50	8 (42.1%)	
50–60	2 (10.5%)	
>60	1 (5.3%)	
Gender		
Male		242 (51.8%)
Female		169 (36.2%)
Not specified		56 (12.0%)
Etiology		
Intellectual disability, not Down syndrome		42 (9.0%)
Down syndrome		318 (68.1%)
Both intellectual disability and Down syndrome		17 (3.6%)
Not specified		90 (19.3%)
Intellectual disability subdivisions		
Mild intellectual disability		78 (16.7%)
Moderate intellectual disability		46 (9.9%)
Mild or moderate intellectual disability		56 (12.0%)
Moderate or severe intellectual disability		33 (7.1%)
Mild–severe intellectual disability		14 (3.0%)
Severe intellectual disability		14 (3.0%)
Profound intellectual disability		8 (1.7%)
Not specified		218 (46.7%)
Study design		
Randomized controlled trial	2 (13.3%)	
Cross-sectional	6 (40.0%)	
Prospective, interventional	7 (46.7%)	
Prospective, noninterventional	0 (0%)	
Reasons for participant exclusion*		
Down syndrome	1 (6.7%)	
Medications that affect physiological response during exercise	1 (6.7%)	
Medical contraindications for exercise	7 (46.7%)	
Abnormal ECG or ecocardiogram	2 (13.3%)	
Physically active–fit	1 (6.7%)	
1-h or more commute	1 (6.7%)	
Significant motor–ambulatory impairment	4 (26.7%)	
Musculoskeletal–orthopaedic impairment	2 (13.3%)	
History of cardiovascular disease or diabetes	1 (6.7%)	
Congenital heart disease	2 (13.3%)	
Inadequate receptive–expressive language or comprehension	1 (6.7%)	
No previous treadmill experience	1 (6.7%)	
Seizure disorder	1 (6.7%)	

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table 8 (*continued*).

Characteristics	No. of studies	No. of subjects
Hypertension	1 (6.7%)	
Mild intellectual disability	1 (6.7%)	
Metabolic disease	1 (6.7%)	
No exclusion criteria listed	7 (46.7%)	
Study prescreening exercise procedures*		
Physician	8 (53.3%)	
Negative exercise test	3 (20.0%)	
Prescreening exercise tool (e.g., PAR-Q or PARmed-X)	2 (13.3%)	
Not stated	6 (40.0%)	
Type of exercise test		
Maximal, cardiopulmonary exercise test	7 (46.7%)	
Submaximal, age-predicted heart rate test	1 (6.7%)	
Submaximal, other	1 (6.7%)	
None, or not stated	6 (40.0%)	
Exercise test modality*		
Cycle ergometer	3 (20.0%)	
Treadmill	9 (60.0%)	
Walk test	4 (9.8%)	
Other (e.g., rowing ergometer)	1 (6.7%)	
Not stated	3 (20.0%)	
Exercise test monitoring*		
Physician-monitored	1 (6.7%)	
ECG	8 (53.3%)	
Blood pressure	4 (26.7%)	
Continuous heart rate	4 (26.7%)	
None–not stated	5 (33.3%)	
Exercise intervention study characteristics: intellectual disability (n = 10)		
Exercise training modality		
Combined aerobic plus resistance training	2 (20.0%)	
Multimodal aerobic training	1 (10.0%)	
Cycle ergometry	2 (20.0%)	
Treadmill walking	3 (30.0%)	
Mixed exercise (including functional exercise)	2 (20.0%)	
Exercise prescription frequency (sessions per wk)		
Mean±SD	3.8±0.8	
0–2	0 (0.0%)	
3	4 (40.0%)	
>3	4 (40.0%)	
Not stated	2 (20.0%)	
Exercise prescription duration (min per session) (cardiovascular) n = 6		
Mean±SD	15.7±13.6	
0–20	3 (50.0%)	
21–30	1 (16.7%)	
>30	1 (16.7%)	
Not reported	1 (16.7%)	
Exercise prescription intensity (cardiovascular) n = 6		
Light–moderate	2 (33.3%)	
Moderate–high	2 (33.3%)	
Not stated	2 (33.3%)	
Exercise prescription intervention length (wk)		
Mean±SD	20.1±13.2	
0–12	3 (30.0%)	
13–23	4 (40.0%)	
≥24	2 (20.0%)	
Not reported	1 (10.0%)	

RIGHTSLINK

Table 8 (*concluded*).

Characteristics	No. of studies	No. of subjects
Exercise training safety monitoring*		
Continuous heart rate	4 (40.0%)	
Intermittent heart rate	2 (20.0%)	
Blood pressure	1 (10.0%)	
Staff supervision (e.g., behaviour, correct technique)	7 (70.0%)	
Not stated	1 (10.0%)	
Exercise intervention setting		
Supervised	7 (66.7%)	
Unsupervised	1 (10.0%)	
Mixed (supervised and unsupervised)	2 (20.0%)	

*Studies could report more than 1 criterion.

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

comparison to the benefits bestowed from regular physical activity (A). Thus, a 3A score has been provided.

Grade for screening and physical activity clearance among populations with psychotic disorders is 3A.

Intellectual disability

Among 15 studies involving 467 participants with intellectual disability, 15 adverse events were specifically reported in 5 studies (Table 14). In addition, adverse events were alluded to in 1 study (Halle et al. 1999). During exercise testing, Fernhall and Tymeson (1987) reported an ST-segment depression during treadmill exercise, and Croce et al. (1998) noted that 4 participants reported irritated shins during isometric Kin-Com strength testing. The depressed ST-segment was the only adverse physiological event reported among 7 studies that involved maximal cardiopulmonary tests on 199 participants.

Among the 10 training studies, adverse events were referred to 4 times. Low back pain was reported for 1 older adult with mild intellectual disability during ball exercises designed to improve balance and gait (Carmeli et al. 2003). Crying to discontinue walking on the treadmill was reported for 8 of 13 children in a study designed to compare the effect of different environmental factors, such as modeling and supervision, on compliance with treadmill walking (Vashdi et al. 2008). Crying was 1 of 9 methods employed by the children to discontinue treadmill walking, but it was the only method to be considered an adverse event. An increase in the incidence of disrobing was reported for 1 participant in the study by Jones et al. (2006). It should also be noted that adverse behavioural events during training (e.g., noncompliance or refusal to participate, running away from a peer mentor, and aggression) were reported by Halle et al. (1999); however, the incidence of these behaviours was not reported. In addition, two thirds of the studies reporting adverse events did not prescreen participants, compared with 22.2% of the studies that did not report adverse events.

One study in this review specifically focused on adverse events. The aim of the study by Cremers and colleagues (1993) was to examine the outcomes of restricted and unrestricted physical activity participation in children and young adults with atlantoaxial instability on motor performance and neurological symptoms. Parents of participants assigned to the restricted activity condition were advised not to allow their child to participate in sports deemed to be a risk factor for neck trauma (e.g., trampoline, diving, wrestling, judo); the control group participated in their usual activities. After 1 year, there were no differences between the groups in atlantoaxial distance, motor performance, or rate of neurological signs, and neurological abnormalities did not change over the year. In terms of appraisal of these studies using the AGREE framework, the collection of evidence is small but seems to be of low risk. Notwithstanding this assessment; consensus opinion (e.g., Rimmer 1999; Health Canada 2002; Birrer 2004) suggests that for individuals with Down syndrome, there may be a risk of injury to the cervical spine. Therefore, a score of Level 3B has been provided.

Grade for screening and physical activity clearance among populations with intellectual disability is 3B.

Conclusions

The purpose of this review was to appraise the evidence for adverse events among populations with dementia, psychological disorders, and intellectual disability. Themes of dementia ($n = 5$), depression ($n = 10$), anxiety disorders ($n = 12$), eating disorders ($n = 4$), psychotic disorders ($n = 4$), and intellectual disability ($n = 15$) were used for grouping of the results. Overall, the small number of studies that reported on the presence or absence of adverse events limits the generalizations that can be made at this time. Further, most studies were not designed with the external validity of naturally occurring adverse events in mind, and displayed a possible risk of bias ranging from moderate to high. The studies reviewed were also limited to those published in English, in peer-reviewed journals, and available through our cited search engines. These limitations suggest that, currently, the recommendations made below should be considered with the appropriate level of caution.

Dementia

Overall, the results for adverse events among people with dementia showed some evidence for risk in each bout of exercise (~5%) and across a short-term exercise program (~40%). The exercise programs included a mix of flexibility, range of motion, strength, and endurance activities; thus, we are unable to appraise the risk of specific modalities at this time. It is important to note, however, that the events were generally not severe (e.g., minor injury, soreness) and were designated as a consequence of comorbidities and aging, not from the presence or absence of dementia specifically. Clinicians and qualified exercise personnel are advised to use the

RIGHTSLINK

Table 9. Adverse events in psychotic disorders research.

Event	No. of events
Total number of adverse events	NA (0%); not clear; no exact number of incidences
Studies with adverse events during exercise testing (n = 1 of 1)	
Cramping	Stated by participants, but no exact number of incidents
Leg pain	Stated by participants, but no exact number of incidents
Studies without adverse events during testing (n = NA)	
Studies with adverse events during exercise training (n = 1 of 4)	
Self-consciousness and self-stigmatizing attitudes	Observed by researchers, but no exact number of incidents

Note: NA, not available.

Table 10. Adverse events in dementia research.

Event	No. of events
Total number of adverse events	184 (43%); 184 subject events out of 427 total no. of subjects
Studies without adverse events during exercise testing (n = 0 of 1)	
No adverse effects to exercise testing	
Studies with adverse events during exercise training (n = 2 of 5)	
Musculoskeletal injury	95
Dizziness	39
Respiration–circulation (e.g., breathlessness)	32
General–unspecified (eg.,. stomach pain)	6
Psychological (e.g., fear of falling)	5
Falls	4
Fall + deep scalp wound	1
Near fall	1
Chest pain	1

Table 11. Adverse events in depression research.

Event	No. of events
Total number of adverse events	33 (3%); 33 subject events out of 1061 total number of subjects
Studies with adverse events during exercise testing (n = 1 of 10)	
Leg pain and cramping	Stated by participants, but no exact number of incidents
Studies without adverse events during training (n = 2 of 10)	
Stated no adverse events during exercise training	2 (20%)
Studies with adverse events during exercise training (n = 7 of 10)	
Post-treatment diarrhoea–loose stool	16
Musculoskeletal injury	9
Pain (unspecified)	2
Chest pain	1
Joint pain–swelling	1
Worsening MDD	2
Increased suicidality	1
Hernia	1
Medical contraindication	1
Suicidal ideation and psychosomatic complaints	Stated by participants, but no exact number of incidents, cause unexplained
Chest pain	Stated by participants, but no exact number of incidents
Joint pain–swelling	Stated by participants, but no exact number of incidents
Self-stigmatization	Observed by researchers

review and recommendations from papers focused on these specific comorbidities.

Recommendation no. 1: No specific changes to the PAR-Q or PARmed-X are necessary for populations with dementia (Grade 3B Evidence).

Psychological disorders

Results of adverse events from the psychological disorders followed a similar low-risk profile. Almost all exercise protocols followed public health guidelines (ACSM 2000; Health Canada 2002), so specifics of adverse events by dose–response are not possible at this time. It is important to note that half of the available studies showed a high risk of bias in answering the question of adverse events. The most common risk of bias was in the screening (inclusion and exclusion criteria) of participants. For example, many of the studies on clinical depression featured participants with no history of pharmacotherapy, suicidal ideation, or psychother-

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table 12. Adverse events in anxiety research.

Event	No. of subjects
Total number of adverse events	15 (1%); 15 subject events out of 802 total number of subjects
Studies with adverse events during exercise testing ($n = 4$ of 6)	
Panic attack	5
Studies without adverse events during testing ($n = 2$ of 6)	
Studies with adverse events during exercise training ($n = 4$ of 6)	
Panic attack	1
Hernia	2
Transient muscle and joint complaints	Stated by participants, but no exact number of incidents
Suicidal ideation and psychosomatic complaints	Stated by participants, but no exact number of incidents, cause unexplained

Table 13. Adverse events in eating disorder research.

Event	No. of events
Total number of adverse events	7 (4%); 7 subject events out of162 total number of subjects
Studies with adverse events during exercise testing ($n = 2$ of 5)	
ST-segment depression for 2–6 min into recovery period	1
Arrhythmia	1
Studies without adverse events during testing ($n = 1$ of 5)	
Stated no adverse events during testing	
Studies with adverse events during exercise training ($n = 1$ of 2)	
Injured, no further explanation	1
Studies without adverse events during exercise training ($n = 1$ of 2)	
Stated no adverse events during exercise training	

Note: Only 2 studies had exercise interventions.

Table 14. Adverse events in intellectual disability research.

Event	No. of events
Total number of adverse events ($n = 6$ of 15)	17 (3.6%); 17 subject events out of 467 total number of subjects
Studies with adverse events during exercise testing ($n = 2$ of 13)	5 (1.6%); 5 subject events out of 310 subjects involved in testing
ST-segment depression during treadmill exercise	1
Shin soreness	4
Studies with adverse events during exercise training ($n = 4$ of 9)	
Disrobing	1
Running away from peer mentor	Stated by authors, but no exact number of incidents
Aggression	Stated by authors, but no exact number of incidents
Crying	8
Back pain during strength exercises	1
Prospective studies of adverse events ($n = 1$)	
Total number of adverse events	0 (0.0%); 0 subject events out of 123 subjects

apy. While these delimitations may improve the internal validity of the study's primary outcome, they limit the generalizability that can be made in terms of adverse events. Finally, several of the anxiety and eating disorder studies featured single bouts of exercise, so extrapolation of the results to a sustained exercise program becomes difficult. Nevertheless, all psychological disorders showed negligible findings. There were a small number of panic attacks due to exercise reported among some of the anxiety disorder populations, but these were within the general probability of attack occurrence, independent of exercise, and should not be interpreted as substantive risk (Meyer et al. 1998; Schmidt et al. 2000). The studies also provide evidence that sustained exercise activity does not appear to trigger panic attacks (Broocks et al. 1997; Meyer et al. 1998). The absolute and relative contraindications appear to be a minimal risk, particularly considering that the benefits of exercise are well established for these populations (Warburton et al. 2007) and, in our judgment, clearly outweigh the small numbers of adverse events in the current literature. It seems likely that disorders that are related or similar to those covered in this review would yield similar findings.

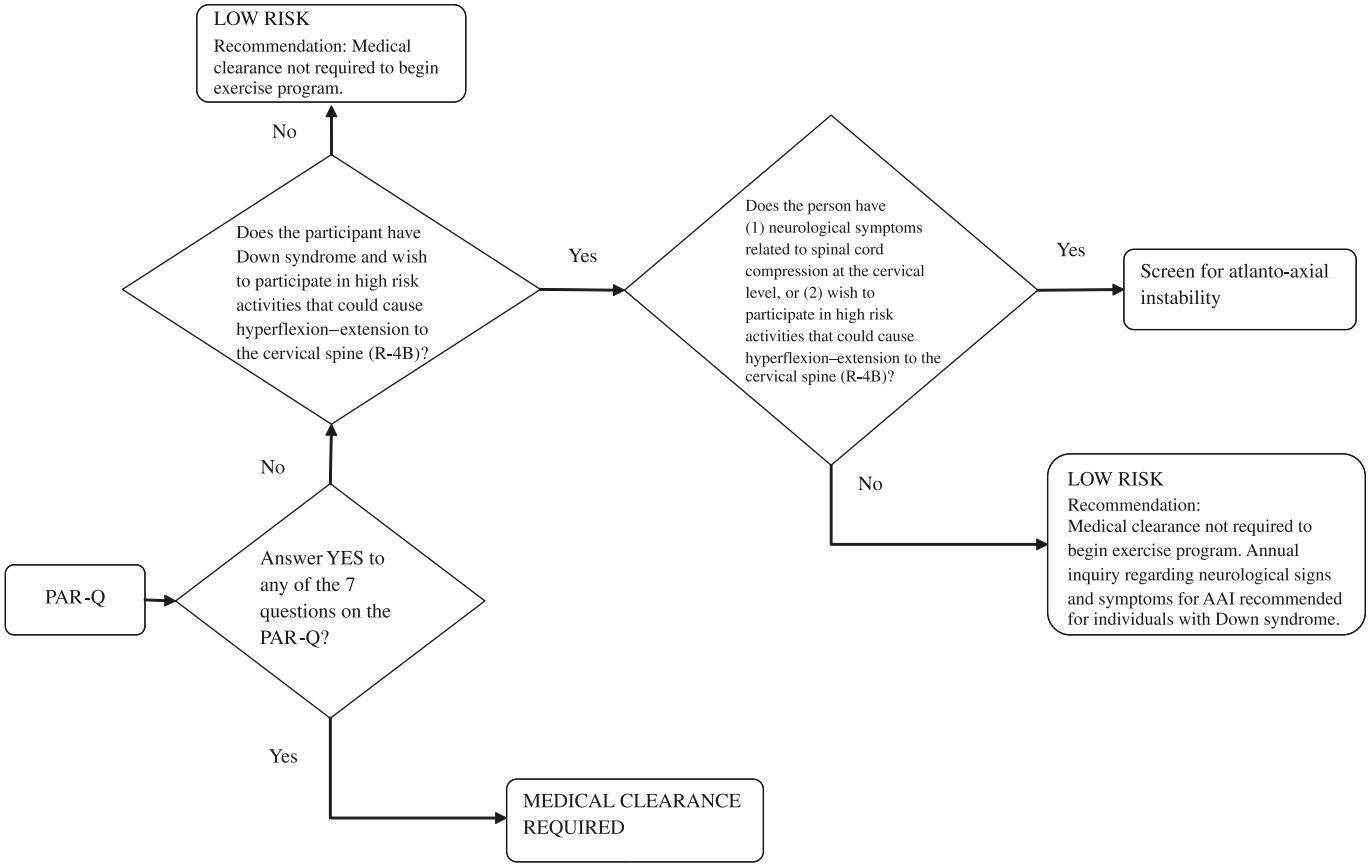
Recommendation no. 2: No specific changes to the PAR-Q or PARmed-X are necessary for populations with depression or related disorders (Grade 3A Evidence).

Recommendation no. 3: No specific changes to the PAR-Q or PARmed-X are necessary for populations with anxiety or related disorders (Grade 3A Evidence).

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Fig. 2. Screening in people with intellectual disability. AAI, antlantoaxial instability; PAR-Q, Physical Activity Readiness Questionnaire; PARmed-X, Physical Activity Readiness Medical Evaluation; R-4B, Grade 4B evidence.



Recommendation no. 4: No specific changes to the PAR-Q or PARmed-X are necessary for populations with eating disorders or related conditions (Grade 3B Evidence).

Recommendation no. 5: No specific changes to the PAR-Q or PARmed-X are necessary for populations with schizophrenia and (or) psychotic disorders or related conditions (Grade 3A Evidence).

Intellectual disability

For people with intellectual disability, the adverse events that occurred could not be characterized as serious. Behavioural adverse events were reported in 3 studies; however, whether these behaviours would have occurred in the absence of exercise is unknown, as no study included a control condition without exercise. What is clear from this review is that studies did not systematically report adverse events during exercise testing and exercise participation; therefore, it is not possible to provide definitive recommendations about the appropriateness of particular protocols. It is also clear that the studies were biased toward excluding people who may have been more at risk of adverse events, and the conditions under which the interventions occurred favoured a person with intellectual disability being involved in community physical activity settings where the PAR-Q may be used for screening and clearance.

One study in this review was designed to examine naturally occurring adverse events from physical activity among individuals with intellectual disability. The absence of adverse events in the study by Cremers et al. (1993) of atlantoaxial instability among children and youth with Down syndrome needs to be considered in relation to current medical opinion. Consensus opinion (for example, Birrer 2004; Tassone and Duey-Holtz 2008; Wind et al. 2004) suggests that cervical spine radiographs are the most reasonable objective measure of cervical abnormality, and that any abnormalities discovered should be followed up with magnetic resonance imaging. However, it has been suggested that identification of symptoms using histories and physical examination may be of greater priority (American Academy of Pediatrics 1995). This recommendation is consistent with one of the conclusions reached by Cremers and colleagues (1993). They concluded that regular radiographic screening of the cervical column was not necessary because there was no difference in atlantoaxial distance, motor performance, or rate of neurological signs between participants restricted from certain activities and those who were unrestricted. In addition, Cremers et al. (1993) found no difference in the number of neurological abnormalities over the year. The current consensus opinion recommends that a yearly examination with inquiry about neurological symptoms or with detection of signs of myelopathy is more useful than radiographic screening (Wind et al. 2004). Indeed, Davidson (1988) reported that among individuals with Down syndrome who had a dislocation, neurological signs were present for several weeks, and often months, before the injury. Consequently, attention should be paid to clinical symptoms, such as neck pain and tilt, gait abnormality, hypertonicity of the lower extremities, weakness, and bladder or bowel incontinence (Sanyer 2006).

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Cremers et al. (1993) also concluded that restriction of sports activities was not necessary. This is not consistent with current consensus opinion for people with Down syndrome who have atlantoaxial instability (Amirfeyz et al. 2006; Birrer 2004; Sanyer 2006; Tassone and Duey-Holtz 2008). Current expert opinion is that individuals with atlantoaxial instability should not participate in activities that pose a high risk of head and neck trauma, such as a diving start in swimming, gymnastics, or alpine skiing.

The lack of weight of evidence on this issue suggests that the more conservative approach is warranted. It is also recommended that for asymptomatic people with Down syndrome, radiographic screening is not necessary unless the individual wishes to engage in high-risk activities that potentially involve trauma to the head or neck (Sanyer 2006; Tassone and Duey-Holtz 2008). However, annual clinical screening for signs and symptoms is needed. A subject review on atlantoaxial instability and Down syndrome by the American Academy of Pediatrics (1995) revealed that of 41 symptomatic patients with atlantoaxial instability, 13 experienced trauma before symptoms appeared and, of these, 3 cases were related to sports. Therefore, for individuals who are clinically symptomatic, radiographic screening and potential follow-up with a spine specialist may be needed (Tassone and Duey-Holtz 2008).

Recommendation no. 6: No specific changes to the PAR-Q or PARmed-X are necessary for populations with non-Down syndrome intellectual disability (Grade 3B Evidence).

Recommendation no. 7: Medical screening for atlantoaxial instability among those with Down syndrome is recommended. An item used to screen for atlantoaxial instability is needed on the PAR-Q or PARmed-X for populations with Down syndrome (Grade 4B Evidence).

Appropriateness of PAR-Q and PARmed-x for exercise screening

Based on the above conclusions, the current PAR-Q and PARmed-X are adequate screening instruments for patients with dementia or psychological disorders. The issues of self-awareness and capability to provide consent, however, need to be made clear on the instrument. As dementia is marked by a decline in cognitive capacity, it is recommended that PAR-Q assentbe provided by a guardian. It is also strongly recommended that a third party who has daily experiences (e.g., care provider) with the client be asked to provide assent. No age-specific delimitations were evident from the review; thus, we conclude that the PAR-Q is appropriate for all ages where consent and assent can be provided.

For people with Down syndrome, the PARQ and the PARmed-x should include a reference to atlantoaxial instability in advice related to musculoskeletal conditions. A decision tree for intellectual disability, provided in Fig. 2, includes a recommendation for medical screening of participants with Down syndrome. No additional considerations were deemed necessary for psychological disorders and dementia; thus, the current item content of the PAR-Q was considered sufficient. It is recommended that assent be provided for those who have dementia and intellectual disability. We suggest that this information be included in the instructions. For intellectual disability, it is recommended that the PAR-Q specifically make reference to the intention of people with Down syndrome to participate in activities that may involve trauma to the head or neck, even among asymptomatic individuals. It is our opinion that atlantoaxial instability may be overlooked as a condition in which "bone or joint problems could worsen on change in physical activity." For those with Down syndrome wishing to participate in activities that could cause hyperflexion and (or) extension of the cervical spine or symptomatic individuals, consulting physicians should enquire about neurological symptoms related to spinal cord compression. Symptoms or the desire to engage in high-risk activities should be followed-up with radiographic screening.

In summary, the benefits of regular physical activity have been established for populations with dementia, psychological disorders, and intellectual disabilities. Our review of adverse events in these populations suggests a relatively low risk of physical activity, with the exception of atlantoaxial instability in populations with Down syndrome. This review, however, highlights the relative paucity of reported presence or absence of adverse events. It is recommended that all future studies carefully document adverse events and include control groups so that naturally occurring base rates can be compared with rates after physical activity participation. The review process also highlights the fact that many studies are at high risk of bias for evidence of naturally occurring adverse events because of the screening in exercise study settings, which limits the external validity of this review.

Acknowledgements

R.E. Rhodes is supported by a salary support award from the Canadian Institutes of Health Research and additional funds from the Social Sciences and Humanities Research Council of Canada and the Canadian Diabetes Association. We also acknowledge the support from the Canadian Public Health Agency and the Canadian Society of Exercise Physiology in the creation of this paper. We thank Sarah Charlesworth, Douglas Race, and Leila A. Pfaeffli for their work on data collection and manuscript preparation.

References

ACSM. 2000. Guidelines for exercise testing and prescription. Lippincott, Williams & Wilkins, Baltimore, Md., USA.

AGREE Collaboration. 2001. Appraisal of Guidelines for Research and Evaluation (AGREE) Instrument. Available from http://www.agreecollaboration.org/instrument/.

AGREE Collaboration. 2003. Development and validation of an international appraisal instrument for assessing the quality of clinical practice guidelines: the AGREE project. Qual. Saf. Health Care, **12**(1): 18–23. doi:10.1136/qhc.12.1.18. PMID:12571340.

Alvarez, N., and Rubin, L. 1986. Atlantoaxial instability in adults with Down sydnrome: A clinical and radiological survey. Appl. Res. Ment. Retard. **7**(1): 67–78. doi:10.1016/0270-3092(86)90019-6. PMID:2938541.

American Academy of Pediatrics. 1995. Atlantoaxial instability in Down syndrome: Subject review. Pediatrics, **96**(1): 151–154. PMID:7596705.

American Association on Mental Retardation. 2002. Mental retardation: definition, classification, and systems of supports. American Association on Mental Retardation, Washington, D.C., USA.

American Psychiatric Association. 2000. Diagnostic and statistical manual of mental disorders DSM-IV-TR. American Psychiatric Association, Arlington, Va., USA.

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Amirfeyz, R., Aspros, D., and Gargan, M. 2006. Down syndrome. Curr. Orthop. **20**(3): 212–215. doi:10.1016/j.cuor.2006.01.003.

Arkin, S.M. 1999. Elder rehab: A student-supervised exercise program for Alzheimer's patients. Gerontologist, **39**(6): 729–735. PMID:10650683.

Atkins, D., Best, D., Briss, P.A., Eccles, M., Falck-Ytter, Y., Flottorp, S., et al.; GRADE Working Group. 2004. Grading quality of evidence and strength of recommendations. BMJ, **328**(7454): 1490–1498. doi:10.1136/bmj.328.7454.1490. PMID:15205295.

Battaglia, A., Bianchini, E., and Carey, J.C. 1999. Diagnostic yield of the comprehensive assessment of developmental delay/mental retardation. Am. J. Med. Genet. **82**(1): 60–66. doi:10.1002/(SICI)1096-8628(19990101)82:1<60::AID-AJMG12>3.0.CO;2-4. PMID:9916845.

Baynard, T., Pitetti, K.H., Guerra, M., and Fernhall, B. 2004. Heart rate variability at rest and during exercise in persons with Down syndrome. Arch. Phys. Med. Rehabil. **85**(8): 1285–1290. doi:10.1016/j.apmr.2003.11.023. PMID:15295754.

Beange, H. 2002. Epidemiological issues. *In* Physical health of adults with intellectual disabilities. *Edited by* V.P. Prasher and M.P. Janicki. Blackwell Publishing, Oxford, UK.

Beange, H., McElduff, A., and Baker, W. 1995. Medical disorders of adults with mental retardation: a population study. Am. J. Ment. Retard. **99**(6): 595–604. PMID:7632427.

Birrer, R.B. 2004. The Special Olympics athlete: evaluation and clearance for participation. Clin. Pediatr. (Phila.) **43**(9): 777–782. doi:10.1177/000992280404300901. PMID:15583772.

Blumenthal, J.A., Babyak, M.A., Moore, K.A., Craighead, W.E., Herman, S., Khatri, P., et al. 1999. Effects of exercise training on older patients with major depression. Arch. Intern. Med. **159**(19): 2349–2356. doi:10.1001/archinte.159.19.2349. PMID:10547175.

Blumenthal, J.A., Babyak, M.A., Doraiswamy, P.M., Watkins, L., Hoffman, B.M., Barbour, K.A., et al. 2007. Exercise and pharmacotherapy in the treatment of major depressive disorder. Psychosom. Med. **69**(7): 587–596. doi:10.1097/PSY.0b013e318148c19a. PMID:17846259.

Bodkin, A.W., Baxter, R.S., and Heriza, C.B. 2003. Treadmill training for an infant born preterm with a grade III intraventricular hemorrhage. Phys. Ther. **83**(12): 1107–1118. PMID:14640869.

Bradley, E., Thompson, A., and Bryson, S. 2002. Mental retardation in teenagers: Prevalence data from the Niagara Region, Ontario. Can. J. Psychiatry, **47**(7): 652–659. PMID:12355677..

Broocks, A., Meyer, T., Bandelow, B., George, A., Bartmann, U., Ruther, E., and Hillmer-Vogel, U. 1997. Exercise avoidance and impaired endurance capacity in patients with panic disorder. Neuropsychobiology, **36**(4): 182–187. doi:10.1159/000119381. PMID:9396017.

Broocks, A., Bandelow, B., Pekrun, G., George, A., Meyer, T., Bartmann, U., et al. 1998. Comparison of aerobic exercise, clomipramine, and placebo in the treatment of panic disorder. Am. J. Psychiatry, **155**(5): 603–609. PMID:9585709.

Canadian Study of Health and Aging Working Group. 1994. Canadian Study of Health and Aging: study methods and prevalence of dementia. CMAJ. **150**(6): 899–913. PMID:8131123.

Carmeli, E., Bar-Chad, S., Lotan, M., Merrick, J., and Coleman, R. 2003. Five clinical tests to assess balance following ball exercises and treadmill training in adult persons with intellectual disability. J. Gerontol. A Biol. Sci. Med. Sci. **58**(8): 767–772. PMID:12902538.

Center, J., Beange, H., and McElduff, A. 1998. People with mental retardation have an increased prevalence of osteoporosis: A population study. Am. J. Ment. Retard. **103**(1): 19–28. doi:10.1352/0895-8017(1998)103<0019:PWMRHA>2.0.CO;2. PMID:9678227.

Centers for Disease Control and Prevention. 2006. Improved national prevalence estimates for 18 selected major birth defects—United States, 1999–2001. MMWR Morb. Mortal. Wkly. Rep. **54**(51): 1301–1305. PMID:16397457.

Chanias, A.K., Reid, G., and Hoover, M.L. 1998. Exercise effects on health-related physical fitness of individuals with an intellectual disability: A meta-analysis. Adapt. Phys. Activ. Q. **15**(2): 119–140.

Clare, L., and Woods, R.T. 2001. Cognitive rehabilitation in dementia. Taylor & Francis Inc., New York, N.Y., USA.

Colcombe, S., and Kramer, A.F. 2003. Fitness effects on the cognitive function of older adults: a meta-analytic study. Psychol. Sci. **14**(2): 125–130. doi:10.1111/1467-9280.t01-1-01430. PMID:12661673.

Corey-Bloom, J. 2000. Dementia. *In* Psychopathology in later adulthood. *Edited by* S.K. Whitbourne. John Wiley & Sons, Inc., New York, N.Y., USA. pp. 217–244.

Cremers, M.J., Bol, E., de Roos, F., and van Gijn, J. 1993. Risk of sports activities in children with Down's syndrome and atlantoaxial instability. Lancet, **342**(8870): 511–514. doi:10.1016/0140-6736(93)91644-2. PMID:8102665.

Croce, R., Horvat, M., and Pitetti, K.H. 1998. Prediction of dynamic strength in individuals with mental retardation. Adapt. Phys. Activ. Q. **9**: 148–178.

Curry, C.J., Stevenson, R.E., Aughton, D., Byrne, J., Carey, J.C., Cassidy, S., et al. 1997. Evaluation of mental retardation: recommendations of a consensus conference: American College of Medical Genetics. Am. J. Med. Genet. **72**(4): 468–477. doi:10.1002/(SICI)1096-8628(19971112)72:4<468::AID-AJMG18>3.0.CO;2-P. PMID:9375733.

Davidson, R.G. 1988. Atlanto-axial instability in individuals with Down syndrome: A fresh look at the evidence. Pediatrics, **81**(6): 857–865. PMID:2966926.

Downs, S.H., and Black, N. 1998. The feasibility of creating a checklist for the assessment of methodological quality both of randomised and non-randomised studies of health care interventions. J. Epidemiol. Community Health, **52**(6): 377–384. doi:10.1136/jech.52.6.377. PMID:9764259.

Dunn, A.L., Trivedi, M.H., and O'Neal, H. 2001. Physical activity dose-response effects on the outcomes of depression and anxiety. Med. Sci. Sports Exerc. **33**(Suppl. 6): S587–S597, discussion 609–610. PMID:11427783.

Dunn, A.L., Trivedi, M.H., Kampert, J.B., Clark, C.G., and Chambliss, H.O. 2005. Exercise treatment for depression: Efficacy and dose response. Am. J. Prev. Med. **28**(1): 1–8. doi:10.1016/j.amepre.2004.09.003. PMID:15626549.

Duraiswamy, G., Thirthalli, J., Nagendra, H.R., and Gangadhar, B.N. 2007. Yoga therapy as an add-on treatment in the management of patients with schizophrenia – a randomized controlled trial. Acta Psychiatr. Scand. **116**(3): 226–232. doi:10.1111/j.1600-0447.2007.01032.x. PMID:17655565.

Durstine, J.L., and Moore, G.E. 2003. ACSM's Exercise Management for Persons with Chronic Diseases and Disabilities. Human Kinetics, Champaign, Ill., USA.

Faulkner, G.E.J. 2005. Exercise as an adjunct treatment for schizophrenia. *In* Exercise, health and mental health. Emerging relationships. *Edited by* G.E.J. Faulkner and A.H. Taylor. Routledge, London., UK. pp. 27–47.

Faulkner, G., and Biddle, S. 1999. Exercise as an adjunct treatment for schizophrenia: A review of literature. J. Ment. Health, **8**(5): 441–457. doi:10.1080/09638239917157.

Faulkner, G.E.J., and Sparkes, A. 1999. Exercise as therapy for schizophrenia: an ethnographic study. J. Sport Exerc. Psychol. **21**(1): 52–69.

Fernhall, B., and Pitetti, K.H. 2001. Limitations to physical work capacity in individuals with mental retardation. Clin. Exerc. Physiol. **3**(4): 176–185.

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Fernhall, B., and Tymeson, G. 1987. Graded exercise testing of mentally retarded adults: a study of feasibility. Arch. Phys. Med. Rehabil. **68**(6): 363–365. PMID:3592950.

Fernhall, B., Tymeson, G., Millar, A.l., and Burkett, L. 1989. Cardiovascular fitness testing and fitness levels of adolescents and adults with mental retardation including Down syndrome. Educ. Train. Ment. Retard. **24**: 133–138.

Gaffney, F.A., Fenton, B.J., Lane, L.D., and Lake, C.R. 1988. Hemodynamic, ventilatory, and biochemical responses of panic patients and normal controls with sodium lactate infusion and spontaneous panic attacks. Arch. Gen. Psychiatry, **45**(1): 53–60. PMID:3337609.

Gallie, K., Graf, P., and Tuokko, H. 1990. Study strategies and their ability to offset memory losses caused by Alzheimer Disease. Can. Assoc. Gerontol. **17**: 32.

Graham, A., and Reid, G. 2000. Physical fitness of adults with an intellectual disability: A 13-year follow-up study. Res. Q. Exerc. Sport, **71**(2): 152–161. PMID:10925812.

Guerra, M., Llorens, N., and Fernhall, B. 2003. Chronotropic incompetence in persons with down syndrome. Arch. Phys. Med. Rehabil. **84**(11): 1604–1608. doi:10.1053/S0003-9993(03)00342-3. PMID:14639558.

Gustafson, S., and Rhodes, R.E. 2006. Parental correlates of physical activity in children and early adolescents. Sports Med. **36**(1): 79–97. doi:10.2165/00007256-200636010-00006. PMID:16445312.

Halle, J.W., Gabler-Halle, D., and Chung, Y.B. 1999. Effects of a peer-mediated aerobic conditioning program on fitness levels of youth with mental retardation: two systematic replications. Ment. Retard. **37**(6): 435–448. doi:10.1352/0047-6765(1999)037<0435:EOAPAC>2.0.CO;2. PMID:10635664.

Harris, A.M., McAlpine, D.E., Shirbhate, R., Manohar, C.U., and Levine, J.A. 2008. Measurement of daily activity in restrictive type anorexia nervosa. Int. J. Eat. Disord. **41**(3): 280–283. doi:10.1002/eat.20486. PMID:18004719.

Health Canada. 2002. Health Canada's Physical Activity Guide. Health Canada, Ottawa, Ont., Canada.

Herman, S., Blumenthal, J.A., Babyak, M.A., Khatri, P., Craighead, W.E., Krishnan, K.R., and Doraiswamy, P.M. 2002. Exercise therapy for depression in middle-aged and older adults: predictors of early dropout and treatment. Health Psychol. **21**(6): 553–563. doi:10.1037/0278-6133.21.6.553. PMID:12433007.

Higgins, J.P.T., and Green, S. 2008. Cochrane Handbook for Systematic Reviews of Interventions. The Cochrane Collaboration. Available from http://www.cochrane-handbook.org/. [Accessed 6 March 2009.]

Jacques, A., and Jackson, G. 2000. Understanding dementia. Churchill Livingstone, New York, N.Y., USA.

Jamnik, V.J., Warburton, D.E.R., Makarski, J., McKenzie, D.C., Shephard, R.J., Stone, J., et al. 2011. Enhancing the effectiveness of clearance for physical activity: background and overall process. Appl. Physiol. Nutr. Metab. **36**(Suppl. 1): This issue.

Jones, M.C., Walley, R.M., Leech, A., Paterson, M., Common, S., and Metcalf, C. 2006. Using goal attainment scaling to evaluate a needs-led exercise programme for people with severe and profound intellectual disabilities. J. Intellect. Disabil. **10**(4): 317–335. doi:10.1177/1744629506070051. PMID:17105740.

Kapell, D., Nightingale, B., Rodriguez, A., Lee, J.H., Zigman, W.B., and Schupf, N. 1998. Prevalence of chronic medical conditions in adults with mental retardation: Comparison with the general population. Ment. Retard. **36**(4): 269–279. doi:10.1352/0047-6765(1998)036<0269:POCMCI>2.0.CO;2. PMID:9713183.

Knapen, J., Van de Vliet, H., Van Coppenolle, H., David, A., Peuskens, J., Pieters, G., and Knapen, K. 2005. Comparison of changes in physical self-concept, global self-esteem, depression and anxiety following two different psychomotor therapy programs in nonpsychotic psychiatric inpatients. Psychother. Psychosom. **74**(6): 353–361. doi:10.1159/000087782. PMID:16244511.

Knubben, K., Reischies, F.M., Adli, M., Schlattmann, P., Bauer, M., and Dimeo, F. 2007. A randomised controlled study on the effects of a short-term endurance training programme in patients with major depression. Br. J. Sports Med. **41**(1): 29–33. doi:10.1136/bjsm.2006.030130. PMID:17062659.

Kramer, A.F., and Erickson, K.I. 2007. Effects of physical activity on cognition, well-being, and brain: Human interventions. Alzheimers Dement. **3**(Suppl. 2): S45–S51. doi:10.1016/j.jalz.2007.01.008. PMID:19595974.

Kramer, A.F., Bherer, L., Colcombe, S.J., Dong, W., and Greenough, W.T. 2004. Environmental influences on cognitive and brain plasticity during aging. J. Gerontol. A Biol. Sci. Med. Sci. **59**(9): M940–M957. PMID:15472160.

Landi, F., Russo, A., and Bernabei, R. 2004. Physical activity and behavior in the elderly: a pilot study. Arch. Gerontol. Geriatr. Suppl. 9: 235–241. doi:10.1016/j.archger.2004.04.033. PMID:15472160.

Lau, D.C.Obesity Canada Clinical Practice Guidelines Steering Committee and Expert Panel. 2007. Synopsis of the 2006 Canadian clinical practice guidelines on the management and prevention of obesity in adults and children. CMAJ, **176**(8): 1103–1106. doi:10.1503/cmaj.070306. PMID:17420493.

Lawlor, D., and Hopker, S. 2001. The effectiveness of exercise as an intervention in the management of depression: systematic review and meta-regression analysis of randomized controlled trials. BMJ, **322**(7289): 763–767. doi:10.1136/bmj.322.7289.763. PMID:11282860.

Lazowski, D.A., Ecclestone, N.A., Myers, A.M., Paterson, D.H., Tudor-Locke, C., Fitzgerald, C., et al. 1999. A randomized outcome evaluation of group exercise programs in long-term care institutions. J. Gerontol. A Biol. Sci. Med. Sci. **54**(12): M621–M628. PMID:10647968.

Lennox, N. 2002. Health promotion and disease prevention. *In* Physical health of adults with intellectual disabilities. *Edited by* V.P. Prasher and M.P. Janicki. Blackwell Publishing, Oxford, UK.

Littbrand, H., Rosendahl, E., Lindelof, N., Lundin-Olsson, L., Gustafson, Y., and Nyberg, L. 2006. A high-intensity functional weight-bearing exercise program for older people dependent in activities of daily living and living in residential care facilities: evaluation of the applicability with focus on cognitive function. Phys. Ther. **86**(4): 489–498. PMID:16579666.

Majnemer, A., and Shevell, M.I. 1995. Diagnostic yield of the neurologic assessment of the developmentally delayed child. J. Pediatr. **127**(2): 193–199. doi:10.1016/S0022-3476(95)70294-6. PMID:7543566.

Martinsen, E.W., Hoffart, A., and Solberg, Y. 1989*a*. Aerobic and nonaerobic forms of exercise in the treatment of anxiety disorders. Stress Med. **5**(2): 115–120. doi:10.1002/smi.2460050209.

Martinsen, E.W., Hoffart, A., and Solberg, Y. 1989*b*. Comparing aerobic with nonaerobic forms of exercise in the treatment of clinical depression: a randomized trial. Compr. Psychiatry, **30**(4): 324–331. doi:10.1016/0010-440X(89)90057-6. PMID:2667882.

Martinsen, E.W., Strand, J., Paulsson, G., and Kaggestad, J. 1989*c*. Physical fitness level in patients with anxiety and depressive disorders. Int. J. Sports Med. **10**(1): 58–61. doi:10.1055/s-2007-1024876. PMID:2703287.

Martinsen, E.W., Raglin, J.S., Hoffart, A., and Friis, S. 1998. Tolerance to intensive exercise and high levels of lactate in panic disorder. J. Anxiety Disord. **12**(4): 333–342. doi:10.1016/S0887-6185(98)00018-8. PMID:9699117.

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

McDevitt, J., Wilbur, J., Kogan, J., and Briller, J. 2005. A walking program for outpatients in psychiatric rehabilitation: pilot study. Biol. Res. Nurs. **7**(2): 87–97. doi:10.1177/1099800405278116. PMID:16267370.

McLaren, J., and Bryson, S.E. 1987. Review of recent epidemiological studies of mental retardation: prevalence, associated disorders, and etiology. Am. J. Ment. Retard. **92**(3): 243–254. PMID:3322329.

Meyer, T., Broocks, A., Bandelow, B., Hillmer-Vogel, U., and Ruther, E. 1998. Endurance training in panic patients: Spiroergometric and clinical effects. Int. J. Sports Med. **19**(7): 496–502. doi:10.1055/s-2007-971951. PMID:9839848.

Ministry of Health and Welfare Canada. 1988. The epidemiology of mental retardation. Ministry of Health and Welfare Canada, Ottawa, Ont., Canada.

Moher, D., Cook, D.J., Eastwood, S., Olkin, I., Rennie, D., and Stroup, D.F. 1999. Improving the quality of reports of meta-analyses of randomised controlled trials: The QUOROM statement. Lancet, **354**(9193): 1896–1900. doi:10.1016/S0140-6736(99)04149-5. PMID:10584742.

Nudel, D.B., Gootman, N., Nussbaum, M.P., and Shenker, I.R. 1984. Altered exercise performance and abnormal sympathetic responses to exercise in patients with anorexia nervosa. J. Pediatr. **105**(1): 34–37. doi:10.1016/S0022-3476(84)80352-2. PMID:6737146.

O'Brien, G., Barnard, L., Pearson, J., and Rippon, L. 2002. Physical health and clinical phenotypes. *In* Physical health of adults with intellectual disabilities. *Edited by* V.P. Prasher and M.P. Janicki. Blackwell Publishing, Oxford, UK.

O'Connor, P.J., Raglin, J.S., and Martinsen, E.W. 2000. Physical activity, anxiety and anxiety disorders. Int. J. Sport Psychol. **31**(2): 136–155.

Ouellette-Kuntz, H., and Paquette, D. 2001. The prevalence of developmental disabilities in Lanark County, Ontario. J. Dev. Disabil. **8**(1): 1–16.

Ouellette-Kuntz, H., Garcin, N., Lewis, M.E.S., Minnes, P., Martin, C., and Holden, J.J.A. 2005. Addressing health disparities through promoting equity for individuals with intellectual disability. Can. J. Public Health, **96**(Suppl. 2): S8–S22. PMID:16078552.

Palleschi, L., Vetta, F., De Gennaro, E., Idone, G., Sottosanti, G., Gianni, W., and Marigliano, V. 1996. Effect of aerobic training on the cognitive performance of elderly patients with senile dementia of Alzheimer type. Arch. Gerontol. Geriatr. **22**(Suppl. 1): 47–50. doi:10.1016/0167-4943(96)86912-3. PMID:18653007.

Pastore, E., Marino, B., Calzolari, A., Digilio, M.C., Giannotti, A., and Turchetta, A. 2000. Clinical and cardiorespiraotory assessment in children with Down syndrome without congenital heart disease. Arch. Pediatr. Adolesc. Med. **154**(4): 408–410. PMID:10768682.

Patja, K., Iivanainen, M., Vesala, H., Oksanen, H., and Ruoppila, I. 2000. Life expectancy of people with intellectual disabilities: A 35-year follow-up study. J. Intellect. Disabil. **44**(5): 591–599. doi:10.1046/j.1365-2788.2000.00280.x.

Petruzzello, S.J., Landers, D.M., Hatfield, B.D., Kubitz, K.A., and Salazar, W. 1991. A meta-analysis on the anxiety-reducing effects of acute and chronic exercise. Sports Med. **11**(3): 143–182. doi:10.2165/00007256-199111030-00002. PMID:1828608.

Pitetti, K.H., and Fernhall, B. 2005. Mental retardation. *In* Exercise testing and exercise prescription for special cases: Theoretical basis and clinical application. *Edited by* J.S. Skinner. Lippincott Williams & Wilkins, Philadelphia. Penn., USA.

Pitetti, K.H., and Tan, D.M. 1991. Effects of a minimally supervised exercise program for mentally retarded adults. Med. Sci. Sports Exerc. **23**(5): 594–601. PMID:2072838.

Pitetti, K.H., and Yarmer, D.A. 2002. Lower body strength of children and adolescents with and without mental retardation: A comparison. Adapt. Phys. Activ. Q. **19**(1): 68–81.

Pitetti, K.H., Millar, A.L., and Fernhall, B. 2000. Reliability of a peak performance treadmill test for children and adolescents with and without mental retardation. Adapt. Phys. Activ. Q. **17**(3): 322–332.

Pitetti, K.H., Yarmer, D.A., and Fernhall, B. 2001. Cardiovascular fitness and body composition of youth with and without mental retardation. Adapt. Phys. Activ. Q. **18**(2): 127–141.

Pommering, T.L., Brose, J.A., Randolph, E., Murray, T.F., Purdy, R. W., Cadamagnani, P.E., and Foglesong, J.E. 1994. Effects of an aerobic exercise program on community-based adults with mental retardation. Ment. Retard. **32**(3): 218–226. PMID:8084274.

Rigaud, D., Moukaddem, M., Cohen, B., Malon, D., Reveillard, V., and Mignon, M. 1997. Refeeding improves muscle performance without normalization of muscle mass and oxygen consumption in anorexia nervosa patients. Am. J. Clin. Nutr. **65**(6): 1845–1851. PMID:9174482.

Rimmer, J.H. 1999. Health promotion for people with disabilities: The emerging paradigm shift from disability prevention to prevention of secondary conditions. Phys. Ther. **79**(5): 495–502. PMID:10331753.

Rimmer, J.H., Heller, T., Wang, E., and Valerio, I. 2004. Improvements in physical fitness in adults with Down syndrome. Am. J. Ment. Retard. **109**(2): 165–174. doi:10.1352/0895-8017(2004)109<165:IIPFIA>2.0.CO;2. PMID:15000673.

Rockwood, K., and Middleton, L. 2007. Physical activity and the maintenance of cognitive function. Alzheimers Dement. **3**(Suppl. 2).: S38–S44. doi:10.1016/j.jalz.2007.01.003. PMID:19595973.

Rolland, Y., Rival, L., Pillard, F., Lafont, C., Rivére, D., Albaréde, J., and Vellas, B. 2000. Feasibility of regular physical exercise for patients with moderate to severe Alzheimer disease. J. Nutr. Health Aging, **4**(2): 109–113. PMID:10842423.

Rolland, Y., Pillard, F., Klapouszczak, A., Reynish, E., Thomas, D., Andrieu, S., et al. 2007. Exercise program for nursing home residents with Alzheimer's disease: a 1-year randomized, controlled trial. J. Am. Geriatr. Soc. **55**(2): 158–165. doi:10.1111/j.1532-5415.2007.01035.x. PMID:17302650.

Sanyer, O.N. 2006. Down syndrome and sport participation. Curr. Sports Med. Rep. **5**(6): 315–318. PMID:17067499.

Schmidt, N.B., Lerew, D.R., Santiago, H., Trakowski, J.H., and Staab, J.P. 2000. Effects of heart-rate feedback on estimated cardiovascular fitness in patients with panic disorder. Depress. Anxiety, **12**(2): 59–66. doi:10.1002/1520-6394(2000)12:2<59::AID-DA1>3.0.CO;2-G. PMID:11091928.

Singh, N.A., Clements, K.M., and Fiatarone, M.A. 1997. A randomized controlled trial of progressive resistance training in depressed elders. J. Gerontol. A Biol. Sci. Med. Sci. **52**(1): M27–M35. PMID:9008666.

Singh, N.A., Stavrinos, T.M., Scarbek, Y., Galambos, G., Liber, C., and Fiatarone-Singh, M.A. 2005. A randomized controlled trial of high versus low intensity weight training versus general practitioner care for clinical depression in older adults. J. Gerontol. A Biol. Sci. Med. Sci. **60**(6): 768–776. PMID:15983181.

Statistics Canada. 2007. Participation and Activity Limitation Survey 2006: Analytical Report. Ottawa, Ont., Canada.

Stein, J.M., Papp, L.A., Klein, D.F., Cohen, S., Simon, J., Ross, D., et al. 1992. Exercise tolerance in panic disorder patients. Biol. Psychiatry, **32**(3): 281–287. doi:10.1016/0006-3223(92)90109-D. PMID:1420644.

Stern, Y. 2002. What is cognitive reserve? Theory and research application of the reserve concept. J. Int. Neuropsychol. Soc. **8**(3): 448–460. doi:10.1017/S1355617702813248. PMID:11939702.

Sundgot-Borgen, J., Rosenvinge, J.H., Bahr, R., and Schneider, L.S.

RIGHTSLINK

2002. The effect of exercise, cognitive therapy, and nutritional counseling in treating bulimia nervosa. Med. Sci. Sports Exerc. **34**(2): 190–195. doi:10.1097/00005768-200202000-00002. PMID:11828224.

Tassone, J.C., and Duey-Holtz, A. 2008. Spine concerns in the Special Olympian with Down syndrome. Sports Med. Arthrosc. **16**(1): 55–60. doi:10.1097/JSA.0b013e3181629ac4. PMID:18277263.

Taylor, C.B., King, R., Ehlers, A., Margraf, J., Clark, D., Hayward, C., et al. 1987. Treadmill exercise test and ambulatory measures in panic attacks. Am. J. Cardiol. **60**(18): 48J–52J. doi:10.1016/0002-9149(87)90683-7. PMID:3425557.

Temple, V.A., Frey, G.C., and Stanish, H.I. 2006. Physical activity of adults with mental retardation. Review and research needs. Am. J. Health Promot. **21**(1): 2–12. PMID:16977907.

Teri, L., Gibbons, L.E., McCurry, S.M., Logsdon, R.G., Buchner, D.M., Barlow, W.E., et al. 2003. Exercise plus behavioral management in patients with Alzheimer disease: A randomized controlled trial. JAMA, **290**(15): 2015–2022. doi:10.1001/jama.290.15.2015. PMID:14559955.

Thompson, J.R., Bryant, B.R., Campbell, E.M., Craig, E.M., Hughes, C.M., Rotholz, D.A., et al. 2004. Supports Intensity Scale (SIS). American Association on Mental Retardation, Washington, D.C., USA.

Tokumura, M., Yoshiba, S., Tanaka, T., Nanri, S., and Watanabe, H. 2003. Prescribed exercise training improves exercise capacity of convalescent children and adolescents with anorexia nervosa. Eur. J. Pediatr. **162**(6): 430–431. PMID:12707771.

Toulotte, C., Fabre, C., Dangremont, B., Lensel, G., and Thevenon, A. 2003. Effects of physical training on the physical capacity of frail, demented patients with a history of falling: a randomized controlled trial. Age Ageing, **32**(1): 67–73. doi:10.1093/ageing/32.1.67. PMID:12540351.

Tuokko, H. 1993. Psychosocial evaluation and management of the Alzheimer's patient. *In* Neuropsychology of Alzheimer's disease and other dementias *Edited by* R. Parks, R. Zec, and R. Wilson. Oxford University Press, New York, N.Y., USA. pp. 565–588.

Tuokko, H., and Hadjistavropoulos, T. 1998. An Assessment Guide to Geriatric Neuropsychology. Lawrence Erlbaum and Associates Inc., Mahwah, N.J., USA.

Ulrich, D.A., Ulrich, B.D., Angulo-Kinzler, R.M., and Yun, J. 2001. Treadmill training of infants with down syndrome: Evidence-based developmental outcomes. Pediatrics, **108**(5): E84–E91. doi:10.1542/peds.108.5.e84. PMID:11694668.

van Schrojenstein Latman-De Valk, H.M.J., Metsemakers, J.F.M., Haveman, M.J., and Crebolder, H.F.J.M. 2000. Health problems in people with intellectual disability in general practice: a comparative study. Fam. Pract. **17**(5): 405–407. doi:10.1093/fampra/17.5.405. PMID:11021900.

Vashdi, E., Hutzler, Y., and Roth, D. 2008. Compliance of children with moderate to severe intellectual disability to treadmill walking: a pilot study. J. Intellect. Disabil. Res. **52**(5): 371–379. doi:10.1111/j.1365-2788.2007.01034.x. PMID:18179510.

Warburton, D.E., Nicol, C., and Bredin, S.S. 2006*a*. Health benefits of physical activity: the evidence. CMAJ, **174**(6): 801–809. doi:10.1503/cmaj.051351. PMID:16534088.

Warburton, D.E., Nicol, C., and Bredin, S.S. 2006*b*. Prescribing exercise as preventive therapy. CMAJ. **174**(7): 961–974. doi:10.1503/cmaj.1040750. PMID:16567757.

Warburton, D.E.R., Katzmarzyk, P.T., Rhodes, R.E., and Shephard, R.J. 2007. Evidence-informed physical activity guidelines for Canadian adults. Appl. Physiol. Nutr. Metab. **32**(Suppl. 2E): S16–S68. doi:10.1139/h07-123.

Warburton, D.E.R., Gledhill, N., Jamnik, V.K., Bredin, S.D.D., McKenzie, D.C., Stone, J., et al. 2011. Evidence-based risk assessment and recommendations for physical activity participation clearance: consensus document. Appl. Physiol. Nutr. Metab. **36**(Suppl. 1): This issue.

Wei, Y., Oakland, T., and Algina, J. 2008. Multigroup confirmatory factor analysis for the adaptive behavior assessment system-II parent form, ages 5–21. Am. J. Ment. Retard. **113**(3): 178–186. doi:10.1352/0895-8017(2008)113[178:MCFAFT]2.0.CO;2. PMID:18407720.

Wind, W.M., Schwend, R.M., and Larson, J. 2004. Sports for the physically challenged child. J. Am. Acad. Orthop. Surg. **12**(2): 126–137. PMID:15089086.

World Heath Organization. 2001. International Classification of Functioning Disability. World Health Organization, Geneva, Switzerland.

Wu, M.K., Wang, C.K., Bai, Y.M., Huang, C.Y., and Lee, S.D. 2007. Outcomes of obese, clozapine-treated inpatients with schizophrenia placed on a six-month diet and physical activity program. Psychiatr. Serv. **58**(4): 544–550. doi:10.1176/appi.ps.58.4.544. PMID:17412858.

Yamaki, K. 2005. Body weight status among adults with intellectual disability in the community. Ment. Retard. **43**(1): 1–10. doi:10.1352/0047-6765(2005)43<1:BWSAAW>2.0.CO;2. PMID:15628929.

Yu, F., Kolanowski, A.M., Strumpf, N.E., and Eslinger, P.J. 2006. Improving cognition and function through exercise intervention in Alzheimer's Disease. J. Nurs. Scholarsh. **38**(4): 358–365. doi:10.1111/j.1547-5069.2006.00127.x. PMID:17181084.

Appendix A

Appendix A appears on the following pages.

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table A1. Studies noting the presence or absence of adverse events during exercise interventions as treatment for dementia.

Study	Study design, exercise sample, and diagnosis	Inclusion–exclusion criteria	Pre-exercise testing and screening criteria	Exercise intervention characteristics	Adverse events in the exercise group
Lazowski et al. 1999	Randomized controlled trial; 68 subjects (M_{age} = 81.3), 2 groups: *FTLC* (n = 36; 7 males, 29 females) *ROM* (n = 32; 2 males, 30 females); 25% of the subjects were diagnosed as having dementia and were recruited from long-term care facilities	Exclusion criteria: cardiovascular or vestibular disorder; uncontrolled hypertension; epilepsy; recent fracture; blind; with minimal assistance	Timed-Get-Up-and-Go test; stair climbing power; isometric, isotonic, grip and upper extremity strength; upper and lower body flexibility	*FLTC Group:* progressive strength training exercises using Therabands, balance and flexibility exercises, and walking *ROM Group:* engaged in full range of motion body movements in seated positions -Both groups trained for 45 min, 3× a wk, for 4 mo in a supervised setting	Stated no deaths, hospitalizations, or exercise-related injuries during the treatment period
Arkin 1999	Prospective interventional; 14 participants (age range = 59–89 y); 13 participants were diagnosed with probable Alzheimer's disease and 1 participant was diagnosed with possible Alzheimer's disease	No inclusion–exclusion criteria stated	Submaximal 6-min walk test; Medex leg press and chest press; Al tests were completed pre- and postintervention	Aerobic exercise: 10 min on the treadmill followed by 10 min on the stationary bike, 2× a wk Resistance training: 2 sets of 10–12 reps with 30 s of rest between sets 11 participants had completed 1 year of the program, whereas 3 have only completed 4 mo	Stated that there were no accidents or injuries
Toulotte et al. 2003	Randomized trial controlled; 20 subjects, 2 groups: *Exercise* (n = 10; M_{age} = 81.0) *Control* (n = 10; M_{age} = 81.9); Subjects MMSE score was <21	Exclusion criteria: unstable medical condition	Timed-Get-Up-and-Go test; chair sit and reach; walking speed over 10 m; posturography platform QFP	Muscle strength using elastic bands, proprioception, balance and flexibility for 45 min, 2× a wk, for 16 wk in a supervised setting	There were no falls in the exercise group during the treatment
Littbrand et al. 2006	Randomized controlled trial; 191 subjects, 2 groups: *Exercise:* (n = 91; M_{age} 85.3; 47 demented: 44 nondemented) *Social activity:* (n = 100)	Inclusion criteria: >65 y; dependent on assistance from 1 or more people, able to stand from a chair with arm rests; MMSE score of <10, physician approval	No mention of pre-exercise testing	Physician clearance for exercise participation; High-Intensity Functional Exercise Program: 45 min, 2.5× a wk for 13 wk; Exercises were selected based on the individual needs of each participant; Subjects performed exercises under supervision	179 adverse events occurred in 1906 exercise sessions among 57 participants (63%) Adverse events were: musculoskeletal (pain–soreness) (53%), dizziness (22%), respiration–circulation (breathlessness) (18%), unspecified discomfort (18%), psychological (fear of falling) (3%), near fall (1%). 2 events were assessed as serious: 1 near fall and 1 pain in chest
Rolland et al. 2007	Randomized controlled trial; 134 subjects, 2 groups: *Exercise* (n = 67; M_{age} = 82.8; 19 males, 48 females) *Routine care* (n = 67; M_{age} = 83.1; 14 males, 53 females) -Met the NINCDS–ADRDA criteria for probable or possible Alzheimer's disease	Exclusion criteria: vascular dementia; Parkinson's disease; contraindication to exercise; and terminal illness with life expectancy less than 12 mo	Physician clearance for exercise participation; 6-min walking speed test, Get-Up-and-Go test, and 1-leg balance test	Combination of strength, flexibility, and balance training; 1 h supervised sessions 2× a wk for 12 mo; Subjects were encouraged to reach moderate breathlessness, but not exhaustion	During exercise training 5 subjects fell; with 1 subject suffering a scalp wound caused by the fall

Note: FTLC, fitness for long-term care; HR, heart rate; M_{age}, mean age; NINCDS–ADRDA, National Institute of Neurological and Communicative Disorders and Stroke–Alzheimer's Disease and Related Disorders Association; PAR-Q, Physical Activity Readiness Questionnaire; PARmed-X, Physical Activity Readiness Medical Evaluation; RPE, rating of perceived exertion; ROM, range of motion.

Published by NRC Research Press

RIGHTSLINK

Table A2. Studies noting the presence or absence of adverse events during exercise interventions as treatment for depression.

Study	Study design, exercise sample, and diagnosis	Inclusion–exclusion criteria	Pre-exercise testing and screening criteria	Exercise intervention characteristics	Adverse events in the exercise group
Martinsen et al. 1989*b*	Randomized controlled trial; 99 subjects, 2 groups: *Aerobic* (n = 52; M_{age} 40.9; 18 males, 33 females) *Non-aerobic* (n = 47; M_{age} = 41.2; 17 males, 30 females); Met DSM-III criteria for major depression, dysthmymic disorder, or depressive disorder; 58 subjects also met criteria for anxiety disorder	Psychotic patients; medical contraindication to exercise	Submaximal exercise test assessed by cycle ergometer according to Aastrand's indirect method	Aerobic exercise consisted of supervised walking or jogging for 1 h at 70% of max aerobic capacity, 3× a wk, for 8 wk	1 subject withdrew due to a hiatus hernia during exercise training
Singh et al. 1997	Randomized controlled trial; 32 subjects, 2 groups: *Exercise* (n = 17; M_{age} = 70; 5 males, 12 females) *Control* (n = 15; M_{age} = 72; 7 males, 8 females); Met DSM-IV criteria for unipolar major or minor depression or dysthymia	Exclusion criteria: dementia; suffering from an unstable disease; bipolar; active psychosis or suicidal ideation; currently seeing a psychiatrist; taking antidepressants within the last 3 mo; engaged in exercise similar to the treatment	1RM using weight machines	Supervised high-intensity progressive resistance training 3× a wk, for 45 min, for 10 wk; Subjects exercised at 80% of their 1RM	1 subject developed increased suicidal ideation; 2 subjects experienced musculoskeletal symptoms
Blumenthal et al. 1999	Randomized controlled trial; 156 subjects, 3 groups: *Exercise* (n = 53; M_{age} = 57; 14 males: 43 females) *Medication* (n = 45; M_{age} = 57; 10 males, 47 females) *Combination* (n = 55; M_{age} = 57; 19 males, 38 females); Met Diagnostic Interview Schedule criteria for MDD	Exclusion criteria: current antidepressant use or other medication that would preclude random assignment; contraindication to exercise or medication treatment; current drug or alcohol abuse; primary psychiatric diagnosis other than MDD; suicidal risk; recent psychotherapy; participation in regular exercise	Maximal graded exercise treadmill test using Balke protocol under continuous ECG recording	The Exercise and Combined groups both engaged in 30 min of supervised walking or jogging 3× a wk at an intensity of 70%–85% of heart rate reserve for 16 wk; Continuous HR and RPE were recorded	7 subjects sustained musculoskeletal injuries during training (4 in the Combined group and 3 in the Exercise group)
Herman et al. 2002	Randomized controlled trial; 156 subjects (M_{age} = 56.7; 43 males, 113 females); 3 groups: *Exercise* (n = 53) *Medication* (n = 48) *Combined* (n = 55); Met DSM-IV criteria for MDD	Exclusion criteria: current antidepressant or medication use; intolerance for the prescribed medication during treatment; suicidal; bipolar; contraindication to exercise	Physician clearance for exercise participation; Maximal treadmill test	The Exercise and Combined groups both engaged in 30 min of supervised cycle ergometry or brisk walking or jogging at an intensity of 70%–85% maximal heart rate 3× a wk for 16 wk; Continuous HR and RPE were recorded	Sstated that there were no pre-existing or emergent physical problems as a reason for discontinuing treatment
Dunn et al. 2005	Randomized controlled trial; 80 subjects (M_{age} = 35.9; 20 males, 60 females), 5 groups: *LD/3* (n = 16), *LD/5* (n = 18), *PHD/3* (n = 17), *PHD/5* (n = 16), *Control* (n = 13); Met DSM-IV criteria for mild to moderate major depression disorder	Exclusion criteria: ≥160% over ideal body weight; consumption of >21 alcoholic drinks–wk; suicidal risk; hospitalization for a psychiatric disorder in the past 5 y; substance abuse; contraindication to exercise; planned or current pregnancy	Physician clearance for exercise participation; Subjects were required to complete six 15-min sessions of light intensity exercise prior to the treatment to test adherence	Supervised treadmill or stationary cycling; *LD/3 and PHD/3* exercised 3× a wk; *LD/5 and PHD/5* exercised 5 days a wk; The length of treatment was 12 wk for all groups; Intensity was based on energy expenditure kcal·kg^{-1}·wk^{-1}; *LD/3 and 5* (7 kcal·kg^{-1}·wk^{-1}); *PHD/3 and 5* (17.5 kcal·kg^{-1}·wk^{-1})	1 subject experienced increased severity of depression; 1 subject had chest pain; 1 subject suffered from joint pain–swelling

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Published by NRC Research Press

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table A2 (*concluded*).

Study	Study design, exercise sample, and diagnosis	Inclusion–exclusion criteria	Pre-exercise testing and screening criteria	Exercise intervention characteristics	Adverse events in the exercise group
Knapen et al. 2005	Randomized controlled trial; 199 subjects, (M_{age} = 35.5; 71 males, 128 females); 2 groups: *Psychomotor Fitness Training* (n = 102) *General Psychomotor Therapy* (n = 97); Met DSM-IV criteria for anxiety disorders (n = 32), mood disorders (n = 63), adjustment disorders (n = 13), personality disorders (n = 70), substance related disorders (n = 10), and other diagnoses (n = 11)	Exclusion criteria: suffer from psychosis; or orthopaedic, neurological, or cardiopulmonary disorder that would prohibit exercise	No mention of pre-exercise screening or testing	2 exercise groups: *Psychomotor Fitness Training*: combination of aerobic exercise and weight training at an intensity ranging from 40%–60% of estimated HRR, 3× a wk; *General Psychomotor Therapy*: 1 × a wk relaxation training, 2 × a wk a variety of physical activities of various intensities; The length of both programs was 16 wk	Reasons for dropout (n = 91) were unrelated to the study; Increased suicidal ideation and psychosomatic complaints were noted in some subjects; cause unexplained
McDevitt et al. 2005	Prospective interventional: 15 subjects, 1 group: (M_{age} 41.1); Psychiatric diagnoses included: schizophrenia or schizoaffective disorder (10), bipolar illness (4), and major depression (1)	Exclusion criteria: cardiopulmonary or cardiovascular disease; past history of myocardial infarction, stroke, or type 1 diabetes; blood pressure ≥160/100 mm Hg; use of beta-blockers, diltiazem, or verapamil; abnormal ECG; contraindication to regular exercise participation	Cardiologist clearance for exercise participation; Maximal exercise test, using Bruce protocol; Subjects were monitored through RPE and continuous HR	Supervised walking, 2–3× a wk, duration progressed from 10 to 30 min for 12 wk; Intensity was kept between 60%–79% of the subjects HR_{max}; HR and RPE gauged exercise intensity	Leg pain and cramping was noted among participants; Stigmatization and self-consciousness may have been adverse effects as noted in field observations
Singh et al. 2005	Randomized controlled trial; 60 subjects, 3 groups: *HIGH* (n = 20; M_{age} = 69; 9 males: 11 females), *LOW* (n = 20; M_{age} = 70; 8 males; 12 females), *General Care* (n = 20; M_{age} = 69; 10 males, 10 females); Met DSM-IV criteria for major depression, minor depression, and dysthymia	Exclusion criteria: dementia; contraindication to exercise; bipolar; active psychosis; suicidal, current psychotherapy; current use of antidepressants	1RM using weight machines	*HIGH*: supervised high-intensity progressive resistance training, training at 80% 1RM; *LOW*: supervised low=intensity progressive resistance training at 20% 1RM; Both groups trained 3× a wk for 8 wk performing 3–8 reps for ~60 min; RPE was each session	2 subjects noted pain: pain was undefined
Blumenthal et al. 2007	Randomized controlled trial; 202 subjects (M_{age} = 52), 4 groups: *Supervised Exercise*, *Home-based Exercise*, *Sertraline*, *Placebo* (n = 51, 53, 49, 49, respectively); Met DSM-IV criteria for major depressive disorder	Other primary psychiatric disorder; contraindication to exercise; current use of antidepressants or psychotropic medication; alcohol or drug abuse; suicidal ideation	Physician clearance for exercise participation; Maximal graded treadmill exercise test; Subjects were under continuous ECG monitoring	Both groups trained for 30 min 3× a wk for 16 wk at an intensity of 70%–85% HRR_{max}; HR and RPE were recorded 3× per session	1 home-based subject experienced worsening depression and another developed a medical contraindication; 21% of home-based exercisers (n = 11) reported worse post-treatment diarrhea and loose stool, along with 10% (n = 5) of the supervised exercisers
Knubben et al. 2007	Randomized controlled trial; 38 subjects, 2 groups: *Exercise* (n = 20; M_{age} = 49; 9 males, 11 females), *Placebo* (n = 18; M_{age} = 50; 8 males, 10 females); Met DSM-IV criteria for treatment of a major depressive episode	Inclusion criteria: score of >12 on the Bech-Rafaelsen Melancholy Scale; Exclusion criteria: organic disease; schizophrenic symptoms; epilepsy; electroconvulsive therapy	Submaximal treadmill test following modified Bruce protocol; Subjects were under continuous ECG monitoring	Supervised treadmill walking for 10 d; Subjects walked 5 times for 3 min at 80% HR_{max}, walking at half-speed for 3 min between workloads; HR and RPE were used to gauge intensity	Stated that subjects reported no negative effects to exercise, such as muscle pain, tightness or fatigue during exercise training

Note: HRR, heart rate reserve; LD, low dose; M_{age}, mean age; PHD, public health dose.

Published by NRC Research Press

RIGHTSLINK

Table A3. Studies noting the presence or absence of adverse events during exercise interventions as treatment for anxiety and panic disorders.

Study	Study design, exercise sample, and diagnosis	Inclusion–exclusion criteria	Pre-exercise testing and screening criteria	Exercise intervention characteristics	Adverse events in the exercise group
Taylor et al. 1987	40 subjects, 3 groups: *Panic Patients* (n = 40; M_{age} = 36.7; 0 males, 40 females), *Control 1*(n = 20; M_{age} = 34), *Control 2* (n = 20; M_{age} = 43); Met Structured Clinical Interview for diagnosis criteria for panic disorder, panic disorder with limited phobic avoidance, or agoraphobia with panic attacks	Pregnancy, lactation; history of seizures or head trauma with unconsciousness; drug–alcohol abuse; renal, hepatic, cardiac, pulmonary, endocrine or collagen disease; involvement in regular vigorous exercise, or reported anxiety on a self-report inventory	Physician clearance for exercise participation; Submaximal cycle ergometer test using a modified Balke protocol; HR was continuously monitored	There was no exercise intervention; Subjects wore a Vitalog MC-2 monitor for 3 d and nights, which measured activity levels and HR	1 panic patient reported a panic attack during the treadmill test; 1 other subject had evidence of treadmill- induced ischemic ST-segment depression
Gaffney et al. 1988	20 subjects, 2 groups: *Anxiety Patients* (n = 10; M_{age} = 38; 4 males, 6 females), *Control Subjects* (n = 10; M_{age} = 32; 5 males, 5 females); Met DSM-III criteria for panic attacks and were suffering a minimum of 3 a wk	No inclusion–exclusion criteria stated	Maximal exercise test using cycle ergometry; Subjects were under continuous ECG monitoring	There was no exercise intervention, only the exercise test	There were no ECG changes of ischemia or any arrhythmias detected during exercise
Martinsen et al. 1989*a*	Randomized controlled trial; 79 subjects, 2 groups: *Aerobic* (n = 36; M_{age} = 39.1; 11 males, 25 females), *Non-aerobic* (n = 43; M_{age} = 38.8; 17 males, 26 females); Met DSM-III-R criteria for anxiety disorders	Met DSM-III-R criteria for an anxiety disorder	Ssubmaximal cycle ergometer test according to Aastrand's indirect method	Aerobic group: brisk walking or jogging at 70% maximum aerobic capacity; Nonaerobic group: strength and flexibility training at a lower intensity; Both groups trained for 30+ min, 3× a wk, for 8 wk, while under supervision	1 subject experienced problems with a hiatus hernia during exercise
Martinsen et al. 1989*b*	90 subjects (M_{age} = 39.3); Met DSM-III criteria for anxiety disorders and depressive disorders; *Anxiety only* (n = 16; 7 males, 9 females), *Depression only* (n = 38; 19 males, 19 females), *Anxiety and depression* (n = 36; 16 males, 20 females)	Contraindication to exercise; and current use of beta-adrenergic blocking agents	2 exercise tests: submaximal exercise *test* on a cycle ergometer following Astrand-Rhyming procedure; maximal exercise *test* on a cycle ergometer; Subjects were monitored through RPE and HR	There was no exercise intervention, only the 2 exercise tests	It was stated that no complications occurred during the tests
Martinsen et al. 1989*c*	Randomized controlled trial; 99 subjects, 2 groups: *Aerobic* (n = 52; M_{age} 40.9; 18 males, 33 females), *Nonaerobic* (n = 47; M_{age} = 41.2; 17 males, 30 females); Met DSM-III criteria for major depression, dysthmymic disorder, or depressive disorder; 58 subjects also met criteria for anxiety disorder	Psychotic patients; medical contraindication to exercise	Submaximal exercise test assessed by cycle ergometer according to Aastrand's indirect method	Aerobic exercise consisted of supervised walking or jogging for one hour at 70% of max aerobic capacity, 3× a wk, for 8 wk	1 subject withdrew due to a hiatus hernia during exercise training
Stein et al. 1992	31 subjects, 2 groups: Panic Patients (n = 16; M_{age} = 35.4; 9 males, 7 females), Control Group (n = 15; M_{age} = 32.2); Met DSM-III-R criteria for panic disorder (n = 9) or agoraphobia with panic attacks (n = 7)	No inclusion–exclusion criteria stated	Submaximal cycle ergometer test according to a modified version of Aastrand's Rhyming Test; Subjects were monitored through RPE, ECG, and continuous HR	There was no exercise intervention, only the exercise test	1 patient had a panic attack during the exercise test

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Published by NRC Research Press

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table A3 (*continued*).

Study	Study design, exercise sample, and diagnosis	Inclusion–exclusion criteria	Pre-exercise testing and screening criteria	Exercise intervention characteristics	Adverse events in the exercise group
Broocks et al. 1997	Prospective interventional; 62 subjects, 2 groups: *Panic Patients*(n = 38; M_{age} = 32.1; 18 males, 20 females), *Control Group* (n = 24; M_{age} = 33.9; 11 males, 13 females); Met DSM-III-R criteria for moderate to severe panic disorder	Pregnancy, lactation, major internal diseases, bipolar affective disorder; severe major depression; psychotic symptoms; drug dependency; anorexia or bulimia nervosa; body weight below 80% of ideal	Physician clearance for exercise participation; Maximal exercise test using cycle ergometry; Tests were conducted pre- and postintervention; Subjects were monitored through RPE, ECG, and HR; A physician was also present during the trials	10-wk aerobic fitness program; Details of the program were not provided	2 of the panic patients suffered panic attacks during exercise testing
Broocks et al. 1998	Randomized controlled; 46 subjects; 3 groups: *Exercise Group* (n = 16; M_{age} = 31.8; 6 males, 10 females), *Medication Group* (n = 15; M_{age} = 33.9; 11 males, 4 females), *Placebo Group* (n = 15; M_{age} = 34.8; 6 males, 9 females); Met DSM-III-R criteria for panic disorder and agoraphobia	Pregnancy, lactation, substantial medical illness, presence of another primary psychiatric disorder, drug–alcohol abuse, eating disorder,<80% ideal body weight, participation in an exercise program comparable to treatment	Physician clearance for exercise participation; Cycle ergometry exercise test (protocol not stated)	Jogging outdoors:≥3× a wk for 10 wk in a both a supervised and unsupervised setting	2 subjects experienced panic attacks during exercise training; Transient muscle and joint pains were noted among participants, causing 1 patient to drop out
Martinsen et al. 1998	35 subjects (M_{age} = 37.5; 11 males, 24 females) Met DSM-III-R criteria for panic disorder with agoraphobia	ECG abnormalities; contraindication to exercise; and using beta-adrenergetic blocking agents	Physician clearance for exercise participation 2 exercise tests: submaximal exercise test on a cycle ergometer following Astrand-Rhyming procedure; supramaximal exercise test on a cycle ergometer Only 24 of the subjects agreed to take part in the supramaximal test	There was no exercise intervention, only the 2 exercise tests	1 female subject was judged as experiencing a panic attack during the supramaximal test
Meyer et al. 1998	Randomized controlled trial: 45 subjects, 3 groups (n = 15 per group): *Endurance Training*, *Clomipramine Placebo*; Met DSM-III-R criteria for panic disorder with or without agoraphobia	Pregnancy, lactation, presence of another primary psychiatric disorder, drug–alcohol abuse, eating disorder, and participation in an exercise program comparable to treatment	Physician clearance for exercise participation; Maximal exercise test using cycle ergometry; Subjects were monitored through ratings of perceived exertion, ECG, and continuous HR	Primarily running, cycling could be substituted 1 session a wk: 3× a wk for 45–60 min a session for 10 wk in both a supervised and unsupervised setting	2 subjects experienced panic attacks during exercise testing
Schmidt et al. 2000	54 subjects; 4 groups: *Panic disorder with HR feedback* (n = 12; M_{age} = 35.6; 7 males, 5 females), *Panic disorder without HR feedback* (n = 15; M_{age} = 38.7; 7 males, 8 females), *Control with HR feedback* (n = 14; M_{age} = 34.8; 7 males, 7 females), *Control without HR feedback* (n = 13; M_{age} = 36.0; 7 males, 6 females); Met DSM-IV criteria for panic disorder	Schizophrenia or organic mental disorder; suicidal intent; use of HR altering medication; history of respiratory, renal, or heart disease; epilepsy or stroke; and smoking	Maximal cycle ergometer exercise test following the United states Air Force protocol; Subjects HR was continuously monitored	There was no exercise intervention, only the 2 exercise tests	2 panic subjects experienced a panic attack during exercise testing

Published by NRC Research Press

RIGHTSLINK

Table A3 (*concluded*).

Study	Study design, exercise sample, and diagnosis	Inclusion–exclusion criteria	Pre-exercise testing and screening criteria	Exercise intervention characteristics	Adverse events in the exercise group
Knapen et al. 2005	Randomized controlled trial; 199 subjects: 71 males; 128 females (M_{age} = 35.5); 2 groups: *Psychomotor Fitness Training* (n = 102), *General Psychomotor Therapy* (n = 97); Met DSM-IV criteria for anxiety disorders (n = 32), mood disorders (n = 63), adjustment disorders (n = 13), personality disorders (n = 70), substance related disorders (n = 10), and other diagnoses (n = 11)	Suffer from psychosis, orthopaedic, neurological, or cardiopulmonary disorder that would prohibit exercise	No mention of pre-exercise screening or testing	2 exercise groups: *Psychomotor Fitness Training*: combination of aerobic exercise and weight training at an intensity ranging from 40%–60% of estimated heart rate reserve 3× a wk; *General Psychomotor Therapy*: 1× a wk relaxation training, 2× a wk a variety of physical activities of various intensities; The length of both programs was 16 wk	Reasons for dropout (n = 91) were unrelated to the study; Increased suicidal ideation and psychosomatic complaints were noted in some subjects; cause unexplained

Note: HR, heart rate; M_{age}, mean age; RPE, Rating of perceived exertion.

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Published by NRC Research Press

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table A4. Studies noting the presence or absence of adverse events during exercise interventions as treatment for eating disorders.

Study	Study design, exercise sample, and diagnosis	Inclusion–exclusion criteria	Pre-exercise testing and screening criteria	Exercise intervention characteristics	Adverse events in the exercise group
Nudel et al. 1984	35 subjects, 2 groups: *Patients* (n = 20; M_{age} = 15.3; 2 males, 18 females), *Control* (n = 15; M_{age} = 15.8; 15 females); Met the American Psychiatric Association criteria for anorexia nervosa	No inclusion–exclusion criteria stated	Maximal cycle ergometer exercise test; ECG was used to monitor the subjects throughout testing	No exercise intervention	5 patients were found to have ST-segment depression of 2 to 4 mm during exercise, which persisted for 2 to 6 min into the the recovery period
Rigaud et al. 1997	30 subjects, 2 groups: *AN Patients* (n = 15; M_{age} = 29.8; 2 males, 13 females), *Control* (n = 15; M_{age} = 33.5; 2 males, 13 females); Met DSM-IV criteria for anorexia nervosa	No inclusion–exclusion criteria stated	Maximal cycle ergometer exercise test; ECG was used to monitor the subjects throughout testing; AN patients were tested 4 times: before, 8, 30, and 45 days after starting refeeding	No exercise intervention	1 patient's first exercise session was terminated at 6 min because of arrhythmia
Sundgot-Borgen et al. 2002	Randomized controlled trial; 64 subjects, 4 groups: *Exercise* (n = 15; M_{age} = 23), *Behavioral Therapy* (n = 16; M_{age} = 22), *Nutritional Advice* (n = 17; M_{age} = 22), *Waiting List Control* (n = 16; M_{age} = 23); Met DSM-IV criteria for bulimia nervosa	No history of anorexia nervosa or other psychiatric or somatic disorders, no treatment for eating disorders for 6 months, no use of medication, eumenorrhea	Physician clearance for exercise participation; Submaximal walk test, using Balke protocol	Combined aerobic and nonaerobic activities; One 1-h group session per wk, advised to exercise ≥2× a wk for 35 min unsupervised; 16-wk program ; Intensity: 50%–70% maximal aerobic uptake	1 subject was injured: cause unexplained
Tokumura et al. 2003	-Prospective interventional; 17 subjects (M_{age} = 14); 2 groups: *Exercise* (n = 9), *Control* (n = 8); Diagnosis of anorexia nervosa	No inclusion–exclusion criteria stated	A test was conducted; however, method and protocol were not given	Stationary cycling for 30 min, 5× a wk at their individual anaerobic threshold in a supervised setting for 6 to 12 mo (mean = 10 mo)	Stated there were no inappropriate responses to exercise
Harris et al. 2008	16 female subjects, 2 groups: *Patients* (n = 8; M_{age} = 36), *Control* (n = 8; M_{age} = 30); Met DSM-IV criteria for restrictive type anorexia nervosa	Not receiving current psychotherapy; BMI >19 $kg \cdot m^{-2}$; smoke; use alcohol, have concurrent psychiatric disorders, pregnant	Submaximal exercise test; Subjects walked at 0.5, 1.0, 1.5, 2.0, 2.5, 3.0 $miles \cdot h^{-1}$ on a calibrated treadmill for 30 min	Nno exercise intervention	Stated that the procedures were well tolerated by the subjects

Note: BMI, body mass index; ECG, electrocardiogram; HR, heart rate; M_{age}, mean age; RPE, rating of perceived exertion.

Published by NRC Research Press

RIGHTSLINK

Table A5. Studies noting the presence or absence of adverse events during exercise interventions as treatment for psychotic disorders.

Study	Study design, exercise sample, and diagnosis	Inclusion–exclusion criteria	Pre-exercise testing and screening criteria	Exercise intervention characteristics	Adverse events in the exercise group
Knapen et al. 2005	Randomized controlled trial; 199 subjects: 71 males, 128 females (M_{age} = 35.5); 2 groups: *Psychomotor Fitness Training* (n = 102), *General Psychomotor Therapy* (n = 97); Met DSM-IV criteria for anxiety disorders (n = 32), mood disorders (n = 63), adjustment disorders (n = 13), personality disorders (n = 70), substance related disorders (n = 10), and other diagnoses (n = 11)	Exclusion criteria: suffer from psychosis; or orthopaedic, neurological, or cardiopulmonary disorder that would prohibit exercise	No mention of pre-exercise screening or testing	2 exercise groups: *Psychomotor Fitness Training*: combination of aerobic exercise and weight training at an intensity ranging from 40%–60% of estimated heart rate reserve 3× a wk, *General Psychomotor Therapy:* 1× a wk relaxation training, 2× a wk a variety of physical activities of various intensities; The length of both programs was 16 wk	Stated that reasons for dropout (n = 91) were unrelatedto the study; Increased suicidal ideation and psychosomatic complaints were noted in some subjects; cause unexplained
McDevitt et al. 2005	Prospective interventional; 15 subjects, 1 group (M_{age} = 41.1); Psychiatric diagnoses included schizophrenia or schizoaffective disorder (n = 10), bipolar illness (n = 4), and major depression (n = 1)	Exclusion criteria: cardiopulmonary or cardiovascular disease; past history of myocardial infarction, stroke, or type 1 diabetes; blood pressure ≥160/100 mm Hg; use of beta-blockers, diltiazem, or verapamil; abnormal ECG; contraindication to regular exercise participation	Cardiologist clearance for exercise participation; Maximal exercise test on a cycle ergometer, following Bruce protocol; Subjects were monitored through RPE and continuous HR	Supervised walking, 2–3× a wk, duration progressed from 10 to 30 min for 12 wk; Intensity was kept between 60%–79% of the subjects HR_{max}; HR and RPE gauged exercise intensity	Leg pain and cramping was noted among participants; Stigmatization and self-consciousness may have been adverse effects as noted in field observations
Duraiswamy et al. 2007	Randomized controlled trial; 61 subjects, 2 groups: *Exercise* (n = 30; M_{age} = 31.3; 23 males, 7 females), *Yoga* (n = 31; M_{age} = 32.5; 19 males, 12 females); Met DSM-IV criteria for schizophrenia	Exclusion criteria: recent myocardial infarction; fracture; seizure disorder; mental retardation; comorbid substance dependence	No mention of pre-exercise screening or testing	Exercise Group: pretraining: brisk walking or jogging 60 $min \cdot d^{-1}$, 5× a wk for 3 wk; Subjects who completed the training continued with their treatment for 3 more months	Stated that there were no serious mental or physical adverse events
Wu et al. 2007	Randomized controlled trial; 53 subjects, 2 groups: *Intervention*(n = 25; 11 males, 14 females), *Control* (n = 28; 11 males, 17 females); Met DSM-IV criteria for schizophrenia	Exclusion criteria: taking antipsychotic or lipid lowering medication; abnormal ambulatory functions or organ failure; severe mental illness or retardation; pregnant or lactating; disability that prevented walking	No mention of pre-exercise screening or testing	20 min of supervised moderate intensity walking up and down stairs 3× a wk for 6 mo	Stated that psychiatric conditions of the patients did not worsen

Note: ECG, electrocardiogram; HR, heart rate; M_{age}, mean age; RPE, rating of perceived exertion.

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Published by NRC Research Press

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table A6. Studies noting the presence or absence of adverse events during exercise testing or exercise interventions involving persons with intellectual disability.

Study	Study design, exercise sample, and diagnosis	Inclusion–exclusion criteria	Pre-exercise testing and screening criteria	Measurements	Exercise intervention characteristics	Adverse events
Bodkin et al. 2003	Case study 1 male infant (age = 8m) with Down syndrome and cerebral palsy	None reported	Not reported	Alberta Infant Motor Scale, stepping pattern video analysis	Treadmill training in conjunction with physical therapy. Treadmill training occurred for 23 wk × 4 d a wk and consisted of 2 × 140 s walking at 15 $cm \cdot s^{-1}$. Supervision by therapists or mother (ratio 1:1)	Stated that treadmill training occurred without adverse events or apparent discomfort
Carmeli et al. 2003	Quasi-experimental 49 participants 3 groups: *Intervention group* (n = 17; 4 males, 13: females; M_{age} = 56.5; IQ range 56–75) *ID control* (n = 12; M_{age} = 60.3; IQ mild ID) *Non-ID control* (n = 20; M_{age} = 60.5)	None reported	Physician clearance required	Timed Get-Up-and-Go, Full turn, Forward reach, Sit-to-stand, 1-legged stand	Ball exercises and treadmill walking for 27 wk × 5 d a wk. Weeks 0, 12, and 27 were testing. Treadmill walking 3 d a wk; ranging from 5–15 min with 0% incline to 30 min with 2%–3% include; as tolerated. Supervised by staff who stood near treadmill. Therapistsled ball exercises designed to improve postural control, balance and strength were undertaken 2 d a wk for 20–30 min	Reported that 1 man stopped at the investigator's request as the result of unexpected low back pain during the ball exercises
Cremers et al. 1993	Quasi-experimental design 135 participants with Down syndrome (age range 6–17 y) 3 groups: *Group A: AAI intervention group* (n = 44, males = 33: females = 11) *Group B: AAI control group* (n = 47, males = 32: females = 15) *Group C: No AAI control group* (n = 44, males = 25: females = 19)	Inclusion criteria: children and youth with Down syndrome. For groups A and B: atlantoaxial distance >4 mm	Not reported	Radiographic screening to assess atlantoaxial distance, infections, accidents, motor test, neurological examination	Group A were asked to stop playing sports that were assessed as "risky" for neck trauma for 1 year	Stated there were no differences between groups A and B in atlantoaxial distance measured in flexion. Also no change in neurological abnormalities over the year
Croce et al. 1998	Cross-sectional correlational 30 participants with mild or moderate ID (M_{age} = 14.3; males = 17: females = 13)	None reported	Not reported	Isometric and isokinetic strength	NA	Irritated lower shins for 4 participants attributed to unpadded muscle tester
Fernhall and Tymeson 1987	Cross-sectional correlational 17 participants with moderate ID (M_{age} = 29.3; males = 8: females = 9)	None reported	Not reported	Graded treadmill test to illicit maximal physiological responses ($\dot{V}O_2$, HR, $\dot{V}_E$)	NA	1× 4 mm ST-segment depression during treadmill exercise
Fernhall et al. 1989	Cross-sectional 38 participants with mild or moderate ID (M_{age} = 24.7; males = 20: females = 18) Down syndrome (n = 14)	Exclusion criteria: medical contraindications for exercise or ambulation problems	Medical clearance required	Graded treadmill test to illicit maximal physiological responses ($\dot{V}O_2$, HR)	NA	Stated that the results of this study show that subjects with Down syndrome can safely undergo maximal exercise testing

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table A6 (*continued*).

Study	Study design, exercise sample, and diagnosis	Inclusion–exclusion criteria	Pre-exercise testing and screening criteria	Measurements	Exercise intervention characteristics	Adverse events
Guerra et al. 2003	Cross-sectional 2 groups: *Group with Down syndrome* 20 participants with mild ID and Down syndrome (M_{age} = 24.2; males = 14: females = 6) *Control group* 20 exercise-trained participants without ID (M_{age} = 21.2; males = 15: females = 5)	Exclusion criteria: cardiac problems, metabolic disease, or orthopaedic problems, medications that affect physiological response during exercise, abnormal ECG or echocardiogram	Medical clearance required, screening history, resting ECG, and echocardiogram	Graded exercise test to exhaustion. Measures were Chronotrophic Response Index and maximal HR	NA	Stated that none of the participants showed any ischemic electrocardiographic changes during the exercise test
Halle et al. 1999	Quasi-experimental design 17 participants with moderate or severe ID 4 groups: *Intervention group 1* (n = 6; 3 males = 3: females = 3; M_{age} = 13.6) *Control group 1* (n = 14; males = 1: females = 2; M_{age} = 12.7) *Intervention group 2* (n = 4; males = 3: females = 1; M_{age} = 17.2) *Control group 1* (n = 4; males = 3: females = 1; M_{age} = 19.5)	Inclusion criteria: ability to walk and participant classified as having moderate or severe ID	Not reported	Minute-by-minute HR during treadmill testing	Intervention groups engaged in 20–21 wk × 3 d a wk; control groups participated in 12–13 wk following baseline. Sessions involved warm up (5 min), of cardiovascular exercise, i.e., walk–jog (15–20 min), and cool down (5 min). Exercise intensity was 70%–85% of the difference between HR_{max} and HR_{rest} monitored intermittently with heart monitors. Supervision by peer (ratio 1:1)	Problem behaviours were exhibited by a few participants (number not stated) during the intervention. These behaviours included running away from peer-mentor and occasional aggression
Jones et al. 2006	Pre-experimental design 22 participants with severe or profound ID (M_{age} = 44.6)	None reported	Medical clearance	Goal attainment in related to challenging behaviour, community access, and physical competence. Health indicators (BP, BMI, O_2 saturation, seizure frequency, and resting HR)	16 wk × 4 d a wk involving mixed exercise, including walking, swimming, hydrotherapy, team games, and rebound therapy (intensity and duration not reported)	1 participant showed an increase in weekly frequency of disrobing
Pastore et al. 2000	Cross-sectional 2 groups:	Children with congenital heart disease were excluded	Medical clearance, cardiorespiratory assessment, echocardiogram	Cardiorespiratory fitness assessed via maximal treadmill test (heart rate response, HR_{max}, exercise duration, BP)	NA	No exercise-induced symptoms (syncope, chest pain, or dyspnea) or arrhythmias

RIGHTSLINK

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Table A6 (*continued*).

Study	Study design, exercise sample, and diagnosis	Inclusion–exclusion criteria	Pre-exercise testing and screening criteria	Measurements	Exercise intervention characteristics	Adverse events
	Group with Down syndrome 42 children with mild–severe ID and Down syndrome (M_{age} = 9.8; males = 25: females = 17) *Control group* No details reported					
Pitetti and Tan 1991	Pre-experimental design 14 participants with moderate ID (M_{age} = 25, 9 males, 5 females)	Persons with Down syndrome were excluded	Medical clearance and screening via ECG and BP	Body weight, % body fat, peak $\dot{V}O_2$	16 wk × 3 d a wk involving 12–25 min of cardiovascular exercise (stationary bicycle); plus 3-min warm up and 3 min-cool down. Work intensity: 50%–70% of peak $\dot{V}O_2$ monitored via heart rate monitor. Supervision by investigator (ratio 1:1)	No adverse ECG events noted during the first pre-training test day. Also stated that during training none of the participants complained of soreness or fatigue
Pommering et al. 1994	Pre-experimental design 14 participants with mild–severe ID (M_{age} = 29.1, 7 males, 5 females)	Full function of all 4 limbs, free of uncontrolled medical disease such as seizures, hypertension, congenital heart defects, or medical contraindications to exercise. Not enrolled in other exercise program	Medical screening and clinical examination including stress test	Cardiorespiratory fitness assessed on bicycle ergometer ($\dot{V}O_{2\ max}$, max O_2 pulse, maximal ventilation, maximal time), % body fat, sit and reach	10 wk × 4 d a wk involving 20–30 min of cardiovascular exercise (stationary bicycle and rowing ergometer) at 85% of maximal pretraining heart rate plus 15-min warm up and 15-min cool down. Intensity monitored via period pulse checks. Exercise was supervised, ratio not reported	Stated that all 14 subjects were able to safety complete the stress test to voluntary termination and no injuries occurred as a result of the study
Rimmer et al. 2004	Randomized controlled trial; 52 participants (M_{age} = 39.4±6.4), 2 groups: *Exercise program* (n = 30; 14 males, 16 females), *Control group* (n = 22; 13 males, 9 females); 86% overweight (17%) or obese (69%)	Inclusion criteria: age, 30–70 y; diagnosis of Down syndrome; sedentary ≥1 year; ≤1-h commute; Able to understand instructions and complete peak $\dot{V}O_2$	*Screening* Medical clearance required. Telephone screening and screening visit. Four participants were diagnosed with potential structural heart disease; following ECG and were cleared to exercise. To be approved for peak $\dot{V}O_2$ testing blood (e.g., CBC, chem-12) and urine tests (e.g., protein, ketones) within normal range	Cardiorespiratory fitness assessed via peak treadmill and bicycle ergometer tests (peak heart rate, $\dot{V}O_2$, $\dot{V}_E$, RQ); 1RM bench press and seated leg press, height, weight, and skinfolds	12 wk × 3 d a wk involving 30–45 min of cardiovascular exercise (choice of recumbent stepper, stationary cycle, treadmill, or elliptical cross-trainer); 15–20 min of muscular strength and endurance; Cardiovascular: 50% – 70% of peak $\dot{V}O_2$ monitored with heart watch monitors. Strength: 1 set 10–20 reps at 70% 1RM. Increase by 10% when able to complete 20 reps in 2 consecutive sessions with correct technique; Participants taught to monitor and report own symptoms (e.g., dizziness). Supervision by exercise physiologist and 2 assistants (ratio ≤1:3)	Stated no unusual ECG symptoms exhibited during exercise testing; $\dot{V}O_2$ reached without abnormal blood pressure response or ECG reading

RIGHTSLINK

Table A6 (*concluded*).

Study	Study design, exercise sample, and diagnosis	Inclusion–exclusion criteria	Pre-exercise testing and screening criteria	Measurements	Exercise intervention characteristics	Adverse events
Ulrich et al. 2001	Randomized controlled trial; 30 infants: 9 with congenital heart disease (7 in treadmill group) 2 groups: *Treadmill group* (n = 15; M_{age} at entry 302 d), *Control group* (n = 15; M_{age} at entry 312 d)	None reported	Medical clearance	Anthropometric measures and locomotor measures (raises self to stand, walks with help, walks independently)	Treadmill walking 5 d a wk for 8 min with at 2 $m \cdot s^{-1}$ until the child demonstrated the ability to walk independently. Supervision by parent (ratio 1:1).	Stated that none of the infants demonstrated observable problems while participating in the training
Vashdi et al. 2008	Cross-sectional 16 children with moderate–severe ID (M_{age} = 8.7; males = 14: females = 2)	Inclusion criteria: ability to walk without assistive devices, previous treadmill experience	Not stated	Number of occurrences of discontinued walking and type of discontinuation	Treadmill walking 5 min; 1 min slow then 4 min at 65%–75% predicted HR_{max} across 4 environmental conditions (close supervision, distant supervision, positive reinforcement, paired modelling)	8 out of 13 children who completed the protocol cried to discontinue walking

Note: 1RM, one-repetition maximum; AAI, atlantoaxial instability; BP, blood pressure; BMI, body mass index; CBC, complete blood count; HR, heart rate; ID, intellectual disability; M_{age}, mean age; NA, not applicable; RQ, respiratory quotient; $\dot{V}_E$, pulmonary ventilation; $\dot{V}O_2$, oxygen uptake; $\dot{V}O_{2\,max}$, maximal oxygen uptake.

Appl. Physiol. Nutr. Metab. Downloaded from www.nrcresearchpress.com by King's College London - CHAN Journals on 09/21/11
For personal use only.

Published by NRC Research Press

RIGHTSLINK