DOI: 10.22122/jrrs.v14i5.3355 Published by Vesnu Publications

Physical Activity in People with Intellectual Disability: A Narrative Review

Javid Mostamand[1], Hamzeh Baharlouei[2]

Review Article

Abstract

Introduction: The levels of physical activity and exercise are two important factors to improve health in people with intellectual disability. Several studies addressed the level of physical activity, and the benefits, cautions, and principles of exercising in this group of disabled people. The aim of the current study was to review the articles related to both topics of intellectual disability and exercise to provide a suitable framework for improving physical activity in people with intellectual disability.

Materials and Methods: Databases including PubMed, PEDro, Science Direct, and Magiran were considered to search, using the keywords physical activity, exercise, intellectual disability, and Down's syndrome to find related articles. Finally, twenty two studies which met the inclusion criteria were selected, and the related data including the level of physical activity, and the benefits and principle of exercise prescription were extracted.

Results: Despite approved benefits of physical activity, the level of exercise in people with intellectual disability was lower than other peer groups. In people with intellectual disability, especially people with Down's syndrome, medical conditions such as cardiovascular, physical, mental, and health disorders should be assessed before prescription of any exercises. Aerobic, resistance, and balance training are the most important exercises in people with intellectual disabilit.

Conclusion: Exercise has a pivotal role for improving health in people with intellectual disability. These people have to pass some medical examinations before prescription of any exercise program.

Keywords: Intellectual disability, Physical activity, Exercise, Down syndrome

Citation: Mostamand J, Baharlouei H. **Physical Activity in People with Intellectual Disability: A Narrative Review.** J Res Rehabil Sci 2018; 14(5): 311-7.

Received: 28.07.2018 Accepted: 12.11.2018 Published: 06.12.2018

Introduction

Intellectual disability (ID) is one of the most common causes of disability in children (1). In this disorder, significant limitations are observed in mental functioning and adaptive behaviors, affecting a wide range of daily social and practical skills (2). According to Fernhall, in 1977, the mental retardation measures included low levels of intelligence [two standard deviations (SDs) below the mean or score below 70 for mild disability and less than 35 for severe disability], limitations on at least two adaptive skills, including communication, self-care, performing housework, social skills, routing, health and safety, performance, work and recreation, as well as disease diagnosis before the age of 18 (3).

The prevalence of non-communicable diseases (NCDs) and premature death in people with ID is higher than in other groups (4) and even these problems occur at a younger age (5). These individuals are more than others at risk of certain diseases such as cardiovascular diseases (CVDs), respiratory diseases, and cancer (6). In addition, complications such as infection, leukemia, and Alzheimer's disease have also been reported in people with Down syndrome (DS) (7). Ligament laxity, decreased muscle tone, muscle weakness, obesity, functional limitation, decreased aerobic capacity, and faster aging process are among the most important physical problems in individuals with ID (8). There is also a higher prevalence of some musculoskeletal disorders (MSDs), such as cerebral palsy (CP), congenital foot deformities, hip

1- Associate Professor, Musculoskeletal Research Center AND Department of Physical Therapy, School of Rehabilitation Sciences, Isfahan University of Medical Sciences, Isfahan, Iran
2- Instructor, Musculoskeletal Research Center AND Department of Physical Therapy, School of Rehabilitation Sciences, Isfahan University of Medical Sciences, Isfahan, Iran
Corresponding Author: Hamzeh Baharlouei, Email: hamzehbaharlouei@gmail.com

deformities, and scoliosis (9). These patients suffer from cardiovascular insufficiency and food poverty more than others (7). The results of a study aimed at examining cardiopulmonary characteristics in people with ID revealed that their tolerance during treadmill walking test was much lower in comparison to their peers (10). The prevalence of overweight and obesity in children with ID has been reported to be 25 and 10%, respectively (9).

The benefits of physical activity on the individuals' health have been well documented and various clinical guidelines state that a certain amount of physical activity is required to maintain health (11). In a study, Momeni and Taheri concluded that social and general self-efficacy in children with DS participating in Olympic Games were significantly higher compared to other children with DS (12). Comparison of 70 boys with ID participating in the Special Olympics of Iran with 68 non-athlete boys with this syndrome showed that there was a significant difference in the flexibility, endurance, strength, speed, and body mass index (BMI) indicators in these two groups (13). The results of the systematic review (14) and meta-analysis (15) studies suggest that exercise therapy is an effective way to improve the health of individuals with ID. Moreover, it can increase the skill-related fitness (16), general health (17), and quality of life (QOL) (18), in addition to declined risk of Alzheimer's disease in this group (19).

Physical fitness is very important for daily activities. Low levels of strength and tolerance can limit individuals' independence (20,21). Some aspects of physical fitness, such as the ability to do delicate tasks by hands, balance, walking speed, grip strength, and cardiopulmonary fitness are directly related to the lifespan of the elderly individuals with ID and can extend it up to 5 years (22). Skill-related physical fitness is a type of fitness that is associated with the ability to perform tasks and differs from the health-related fitness. Elements of this type of fitness include agility, balance, coordination, strength, speed, and reaction (16).

Despite the advantages mentioned earlier, physical activity levels in people with ID appear to be low (23). The Sedentary Behavior Research Network (SBRN) defines the sedentary behavior as an activity in which the energy consumption is less than 1.5 metabolic units and this amount of energy is consumed in situations such as sitting, leaning, and lying down (24). In mental disability, the individual's performance decreases in standard physical fitness tests such as strength, endurance, flexibility, motor coordination, and cardiovascular tolerance (25). Golubovic et al. found that physical fitness of people with ID was significantly lower than their gender and age-matched peers (26). The findings in a study indicated that the level of physical activity in individuals aged 50 years old with ID was similar to the 70-year-old individuals (27). This is more prominent in children because the results of the longitudinal studies have shown that cardiovascular risk factors such as high cholesterol, hypertension, and overweight are transmitted from childhood to adulthood (28,29).

Despite the great importance of physical activity in individuals with ID, there seems to be limited investigations in this area exploring various aspects of exercise in this group to be used by physiotherapists. Therefore, the present study was carried out with the aim to examine the latest evidence on the importance, risks, pre-exercise examinations, and exercise prescription principles in individuals with ID, including patients with DS, with an emphasis on clinical points applicable in physiotherapy clinics.

Materials and Methods

English papers were searched on PubMed, ScienceDirect, and PEDro databases using the keywords including "Physical activity, Exercise, Intellectual disability, and Down syndrome". Furthermore, the Magiran database was also reviewed for Persian articles with the keywords "Physical activity, Exercise, Intellectual disability (Mental retardation), and Down syndrome". The time period chosen for the search was the entire September, 2019. The English or Persian studies were selected with the target population consisting of people with ID in general or DS in particular. Besides, the studies were aimed at answering one of the questions of "What are the causes of low level of physical activity in people with ID?", "What are the risks and constraints of exercise in people with ID?", "What kind of exercise is suitable for people with ID?", and "What are some ways to encourage people with ID to exercise?"

Implementing the vocabulary selection process and the method of searching and reviewing the papers and abstracts, the main text of 22 papers was selected and their information was extracted.

Results

22 studies including 18 English-language and 4 Persian-language articles were included in the study. Among the articles reviewed, 4 (11,14-16), 8 (8,12,30-35), and 10 (7,13,17,19,20,25,27,36,37) were guidance or systematic review articles, intervention articles, and non-intervention articles,

respectively. Among the interventional studies, 2 (8,30), 1 (31), 1 (33), 1 (12), 1 (35), and 2 (32,34) papers were conducted on the effect of aerobic exercise, effect of treadmill walking, strength training, effect of participation in Special Olympics, Tai Chi effect, and general exercise program similar to morning exercise, respectively. Additionally, 3 (25,30,37) and 4 (8,12,33,34) articles were respectively conducted on patients with ID and patients with DS, and other articles were performed on individuals with mental disabilities in general. The time period for the selected articles was between 1999 and 2019.

Given the results, it seems that the most important causes of low level of physical activity in individuals with ID are attention problems (36) and motor problems (38). The most important exercises included aerobic, resistance, and balance exercises (14). Along with these, sports such as Tai Chi can also be helpful for these people (35). Fatigue is one of the important factors in the arrangement of exercise programs that requires more careful consideration given the differences in its features and symptoms in people with ID (37). A pre-exercise health examination is essential (11) and is more important in people with DS (39). Exercises should be performed under the supervision of a therapist (33). The daily rehabilitation center with an environment familiar to the disabled individual as well as a fixed physiotherapist are issues that enhance the effectiveness of exercise therapy (33).

Discussion

On the basis of the findings in the present study, one of the causes of low level of physical activity in people with ID is attention problems (36) and motor problems (38). Aerobic, resistance, and balance exercises are recommended for these people more than other sports (14). A pre-exercise health examination is essential (11) and is more important in people with DS (39). The daily rehabilitation center with an environment familiar to the disabled individual as well as a fixed physiotherapist are issues that enhance the effectiveness of exercise therapy (33). The answer to each of the four study questions are presented in details in the following.

What are the causes of low level of physical activity in people with ID? Various causes have been reported for lower levels of physical activity in people with ID, most notably mental retardation and attention deficit disorder (ADD), motor impairment (38), sedentary lifestyle (31), and lack of sufficient motivation to show physical abilities (30).

What are the risks and constraints of exercise in people with ID? Although exercise therapy is useful to the general health of all individuals, especially those with ID (11), health examinations prior to any exercise seem to be necessary (11). These examinations in individuals with ID include cardiovascular, muscle strength, and body composition examinations (11). Health examinations are more important in patients with DS because half of them are at risk for congestive heart failure (CHF) and atlantoaxial instability (AAI) (39). There are several environmental and personal barriers to exercise for people with ID (40). Some diseases, such as epilepsy, respiratory problems, and sensory-motor disorders can also limit their physical activity (41). Group exercise is difficult for most individuals with ID and they require special attention and special individualized treatment (42).

What kind of exercise is suitable for people with ID? Some people with ID can reach a level of ability to perform exercises without supervision, but in many of them, the constant care is necessary (11). Since the risk of AAI is high in children with DS, movements involving the neck or back bending are forbidden. In these children, instability and loss of muscle tone are serious problems. Therefore, strengthening exercises, in particular in the important muscles around the joints, is a priority. Participation in sports such as martial arts and soccer should be exercised with extreme caution (11).

Bartlo and Klein suggested three types of exercise, including aerobic, resistance, and balance training for people with ID (14).

Balance training plays an important role in the lives of people with ID. Increased risk of falls in these individuals occurs at a younger age than in other groups (43). By examining 1515 people with ID, Hsieh et al. reported the female gender, arthritis, epilepsy, taking more than four medications, use of assistive devices, and the inability to lift weights above 4.5 kg as the most important risk factors for falls (42).

Strength training is also useful for people with ID (16). Lower extremity strengthening leads to the improved agility, balance, power, strength, and reaction time (16). Moderate-to-high-intensity training seems to be less necessary in people with ID as it does not affect their functional abilities (44).

Aerobic exercise is an important part of physical activity. Due to low cognitive need, acceptable cost-benefit ratio, low side effects, and high compliance level, walking is one of the practical options for improving aerobic capacity in people with ID (11).

In addition to the basic exercises mentioned, some complementary medicine exercises such as Tai Chi can also help improve the health among individuals with ID. A study on 66 individuals with ID indicated that 12 weeks of Tai Chi training could improve strength and coordination of the upper and lower extremities (35).

What are some ways to encourage people with ID to exercise? There are various ways to encourage people with ID to exercise (11,32,34). Watching others exercise is one of the encouragement methods (11). The results of the study accomplished by Podgorski et al. suggested that even those who were initially uninterested in exercising became interested in practicing exercise after watching others exercise. Verbal instruction and feedback should be simple and expressed in one sentence (32). In their study, Ghasemi et al. concluded that exercise therapy in obese children with DS might even lead to more improvement in cognitive and motor skills compared to the obese healthy ones (34).

Day care centers are good places to perform physical activity (33). At such centers, the physiotherapists and staff are familiar with the personality traits of the individuals with disability and their level of mental ability and, on the other hand, the patients are familiar with their surrounding environment (33). The new environment or therapist can reduce their concentration or even aggravate inappropriate behaviors (42). The environment and equipment must be provided to perform a variety of exercises (33). Moreover, the lower the cost of performing an exercise, the longer the time of performing it, as the family will be able to afford the medical costs for a longer time (33). The safety of the sport environment should also be carefully examined to prevent falls and reduce fear of falling (11).

One of the most important issues in sports is fatigue. Exercise-related neuromuscular fatigue is defined as the decrease in the force or power of the maximum voluntary contraction in a muscle or muscle group as a result of the physical activity (45). This decrease is often associated with an increased perceived exertion to apply the desired force (45). Fatigue can be estimated by either reduced maximum force or power or the inability to maintain the desired force (46). People with lower levels of maximum force (such as children) appear to have a greater ability to continue training compared to those with higher levels of maximum force (47). To ask someone about the fatigue level, one should never use the term “are you tired?” Many people will answer “yes” in such situations, regardless of the level of fatigue. Instead, the phrase “Can you still keep practicing with energy?” is better to be used (11).

The results of the study by Zafeiridis et al. on subjects with ID showed that decreased strength and fatigue during repeated knee extension and flexion occurred later than those in the non-affected individuals, which might be due to less lactate accumulation when implementing fatigue protocols (37). Increasing the accumulation of anaerobic metabolisms such as lactate has a negative effect on muscle irritability (48).

Limitations

In the present study, gray literature such as dissertations and abstracts of congress proceedings were not included.

Recommendations

Future investigations are suggested to address the issue of physical activity in people with ID with a focus on a type of disability such as DS or mental retardation.

Conclusion

Low levels of physical activity in people with ID have various mental and physical causes. This level of activity can be enhanced by practicing appropriate exercise, using motivational techniques, and practicing in the right environment. Aerobic, strengthening, and balance exercises are useful activities for individuals with ID. Before performing any exercise, it is necessary to check the health and fitness status of people with ID.

Acknowledgments

The authors would like to appreciate all the collaborators implementing the Joint Disability and Integration Plan between Isfahan, Iran, and Hamburg, Germany.

Authors’ Contribution

Javid Mostamand: Study design and ideation, Study support, executional, and scientific services, data collection, analysis and interpretation of results, manuscript arrangement, manuscript expert evaluation for scientific concepts, final manuscript

verification for submission to the journal office; Hamzeh Baharlouei, Study design and ideation, study support, executional, and scientific services, data collection, analysis and interpretation of results, manuscript arrangement, manuscript expert evaluation for scientific concepts, final manuscript verification for submission to the journal office, responsibility for maintaining the integrity of the study process from beginning to publication, and responding to the referees' comments.

Funding

This review study was funded by the amounts obtained from the Joint Disability and Integration Plan between Isfahan and Hamburg.

Conflict of Interests

The authors declare no conflicts of interest. Dr. Javid Mostamand has been an Associate Professor, Department of Physical Therapy, School of Rehabilitation Sciences, Isfahan University of Medical Sciences, Isfahan, Iran, since 1995 and Hamzeh Baharlouei has been a lecturer in the Department of Physical Therapy, School of Rehabilitation Sciences, Isfahan University of Medical Sciences.

References

1. Yu C, Li J, Liu Y, Qin W, Li Y, Shu N, et al. White matter tract integrity and intelligence in patients with mental retardation and healthy adults. Neuroimage 2008; 40(4): 1533-41.
2. Luckasson R, Schalock RL. Defining and applying a functionality approach to intellectual disability. J Intellect Disabil Res 2013; 57(7): 657-68.
3. Fernhall B. Mental retardation. In: American College of Sports Medicine, Durstine JL, Moore GE, editors. ACSM's exercise management for persons with chronic diseases and disabilities. Champaign, IL: Human Kinetics; 1977. p. 221-6.
4. Day SM, Strauss DJ, Shavelle RM, Reynolds RJ. Mortality and causes of death in persons with Down syndrome in California. Dev Med Child Neurol 2005; 47(3): 171-6.
5. Reppermund S, Trollor JN. Successful ageing for people with an intellectual disability. Curr Opin Psychiatry 2016; 29(2): 149-54.
6. Higgins S. Physical health of adults with intellectual disabilities. Learning Disability Practice 2004; 7(10): 25-6.
7. Baynard T, Pitetti KH, Guerra M, Unnithan VB, Fernhall B. Age-related changes in aerobic capacity in individuals with mental retardation: A 20-yr review. Med Sci Sports Exerc 2008; 40(11): 1984-9.
8. Boer PH, Moss SJ. Effect of continuous aerobic vs. interval training on selected anthropometrical, physiological and functional parameters of adults with Down syndrome. J Intellect Disabil Res 2016; 60(4): 322-34.
9. Wouters M, Evenhuis HM, Hilgenkamp TIM. Physical fitness of children and adolescents with moderate to severe intellectual disabilities. Disabil Rehabil 2019; 1-11. [Epub ahead of print].
10. Boonman AJN, Schroeder EC, Hopman MTE, Fernhall BO, Hilgenkamp TIM. Cardiopulmonary profile of individuals with intellectual disability. Med Sci Sports Exerc 2019; 51(9): 1802-8.
11. American College of Sports Medicine, Franklin BA, Whaley MH, Howley ET, Balady GJ. ACSM's guidelines for exercise testing and prescription. Philadelphia, PA: Lippincott Williams and Wilkins; 2000. p. 299-305.
12. Momeni M, Taheri HR. The effect of Special Olympics programs on Down syndrome people's self-efficacy. J Rehab 2013; 13(4): 100-7.
13. Fadaei-Dehcheshmeh M, Shamsi-Majelan A.. Comparison of physical fitness in persons with intellectual disability with and without experience of Special Olympics Iran. J Res Rehabil Sci 2018; 14(3): 175-82. [In Persian].
14. Bartlo P, Klein PJ. Physical activity benefits and needs in adults with intellectual disabilities: systematic review of the literature. Am J Intellect Dev Disabil 2011; 116(3): 220-32.
15. Shin IS, Park EY. Meta-analysis of the effect of exercise programs for individuals with intellectual disabilities. Res Dev Disabil 2012; 33(6): 1937-47.
16. Jeng SC, Chang CW, Liu WY, Hou YJ, Lin YH. Exercise training on skill-related physical fitness in adolescents with intellectual disability: A systematic review and meta-analysis. Disabil Health J 2017; 10(2): 198-206.
17. Robertson J, Emerson E, Gregory N, Hatto C, Turner S, Kessissoglou S, et al. Lifestyle related risk factors for poor health in residential settings for people with intellectual disabilities. Res Dev Disabil 2000; 21(6): 469-86.
18. Walsh PN. Ageing and health issues in intellectual disabilities. Curr Opin Psychiatry 2005; 18(5): 502-6.

19. Lifshitz H, Merrick J, Morad M. Health status and ADL functioning of older persons with intellectual disability: community residence versus residential care centers. Res Dev Disabil 2008; 29(4): 301-15.
20. Hilgenkamp TI, van WR, Evenhuis HM. (Instrumental) activities of daily living in older adults with intellectual disabilities. Res Dev Disabil 2011; 32(5): 1977-87.
21. Oppewal A, Hilgenkamp TI, van WR, Schoufour JD, Evenhuis HM. Physical fitness is predictive for a decline in daily functioning in older adults with intellectual disabilities: results of the HA-ID study. Res Dev Disabil 2014; 35(10): 2299-315.
22. Oppewal A, Hilgenkamp TIM. Physical fitness is predictive for 5-year survival in older adults with intellectual disabilities. J Appl Res Intellect Disabil 2019; 32(4): 958-66.
23. Stanish HI, Curtin C, Must A, Phillips S, Maslin M, Bandini LG. Does physical activity differ between youth with and without intellectual disabilities? Disabil Health J 2019; 12(3): 503-8.
24. Tremblay MS, Aubert S, Barnes JD, Saunders TJ, Carson V, Latimer-Cheung AE, et al. Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. Int J Behav Nutr Phys Act 2017; 14(1): 75.
25. Franciosi E, Baldari C, Gallotta MC, Emerenziani GP, Guidetti L. Selected factors correlated to athletic performance in adults with mental retardation. J Strength Cond Res 2010; 24(4): 1059-64.
26. Golubovic S, Maksimovic J, Golubovic B, Glumbic N. Effects of exercise on physical fitness in children with intellectual disability. Res Dev Disabil 2012; 33(2): 608-14.
27. Hilgenkamp TI, van WR, Evenhuis HM. Low physical fitness levels in older adults with ID: Results of the HA-ID study. Res Dev Disabil 2012; 33(4): 1048-58.
28. Raitakari OT, Juonala M, Kahonen M, Taittonen L, Laitinen T, Maki-Torkko N, et al. Cardiovascular risk factors in childhood and carotid artery intima-media thickness in adulthood: The Cardiovascular Risk in Young Finns Study. JAMA 2003; 290(17): 2277-83.
29. Andersen LB, Hasselstrom H, Gronfeldt V, Hansen SE, Karsten F. The relationship between physical fitness and clustered risk, and tracking of clustered risk from adolescence to young adulthood: Eight years follow-up in the Danish Youth and Sport Study. Int J Behav Nutr Phys Act 2004; 1(1): 6.
30. Halle JW, Gabler-Halle D, Chung YB. Effects of a peer-mediated aerobic conditioning program on fitness levels of youth with mental retardation: two systematic replications. Ment Retard 1999; 37(6): 435-48.
31. Lotan M, Isakov E, Kessel S, Merrick J. Physical fitness and functional ability of children with intellectual disability: Effects of a short-term daily treadmill intervention. ScientificWorldJournal 2004; 4: 449-57.
32. Podgorski CA, Kessler K, Cacia B, Peterson DR, Henderson CM. Physical activity intervention for older adults with intellectual disability: report on a pilot project. Ment Retard 2004; 42(4): 272-83.
33. Shields N, Taylor NF, Dodd KJ. Effects of a community-based progressive resistance training program on muscle performance and physical function in adults with Down syndrome: a randomized controlled trial. Arch Phys Med Rehabil 2008; 89(7): 1215-20.
34. Ghasemi A, Momeni M, Sohrabi M. The effect of sport activities on perceptual-motor skills among obese children with Down syndrome. J Rehab 2015; 16(2): 168-75. [In Persian].
35. Kong Z, Sze TM, Yu JJ, Loprinzi PD, Xiao T, Yeung AS, et al. Tai Chi as an alternative exercise to improve physical fitness for children and adolescents with intellectual disability. Int J Environ Res Public Health 2019; 16(7).
36. Vuijk PJ, Hartman E, Scherder E, Visscher C. Motor performance of children with mild intellectual disability and borderline intellectual functioning. J Intellect Disabil Res 2010; 54(11): 955-65.
37. Zafeiridis A, Giagazoglou P, Dipla K, Salonikidis K, Karra C, Kellis E. Muscle fatigue during intermittent exercise in individuals with mental retardation. Res Dev Disabil 2010; 31(2): 388-96.
38. Westendorp M, Houwen S, Hartman E, Visscher C. Are gross motor skills and sports participation related in children with intellectual disabilities? Res Dev Disabil 2011; 32(3): 1147-53.
39. Dedlow ER, Siddiqi S, Fillipps DJ, Kelly MN, Nackashi JA, Tuli SY. Symptomatic atlantoaxial instability in an adolescent with trisomy 21 (Down's syndrome). Clin Pediatr (Phila) 2013; 52(7): 633-8.
40. Kuijken NM, Naaldenberg J, Nijhuis-van der Sanden MW, van Schrojenstein-Lantman de Valk HM. Healthy living according to adults with intellectual disabilities: Towards tailoring health promotion initiatives. J Intellect Disabil Res 2016; 60(3): 228-41.
41. Seddon PC, Khan Y. Respiratory problems in children with neurological impairment. Arch Dis Child 2003; 88(1): 75-8.
42. Hsieh K, Rimmer J, Heller T. Prevalence of falls and risk factors in adults with intellectual disability. Am J Intellect Dev

Disabil 2012; 117(6): 442-54.
43. Hale LA, Mirfin-Veitch BF, Treharne GJ. Prevention of falls for adults with intellectual disability (PROFAID): A feasibility study. Disabil Rehabil 2016; 38(1): 36-44.
44. Carmeli E, Reznick AZ, Coleman R, Carmeli V. Muscle strength and mass of lower extremities in relation to functional abilities in elderly adults. Gerontology 2000; 46(5): 249-57.
45. Enoka RM, Stuart DG. Neurobiology of muscle fatigue. J Appl Physiol (1985) 1992; 72(5): 1631-48.
46. Gandevia SC. Spinal and supraspinal factors in human muscle fatigue. Physiol Rev 2001; 81(4): 1725-89.
47. Hatzikotoulas K, Patikas D, Ratel S, Bassa E, Kotzamanidis C. Central and peripheral fatigability in boys and men during maximal contraction. Med Sci Sports Exerc 2014; 46(7): 1326-33.
48. Fitts RH. Cellular mechanisms of muscle fatigue. Physiol Rev 1994; 74(1): 49-94.