Original Research Article

Comparison of muscle strength and endurance between alcoholics and non-alcoholics

Indumathi M, Viji Devanand , Subathra S, Lovie Beneta T, Celine D, Umayal CC

Department of Physiology, Stanley Medical College, The Tamil Nadu Dr. MGR Medical University, Chennai, Tamil Nadu, India

Abstract

Background: Alcoholics have restricted physical capacity, which could possibly be due to decreased muscle strength and endurance. Alcohol has an effect of reducing muscle protein synthesis. In addition to this, alcohol's inhibitive effect on gluconeogenesis prevents these cells from producing adenosine triphosphate (ATP), which is the source of energy for muscle contraction. **Aim:** The aim of this study was to compare the muscle strength and endurance between alcoholics who were alcohol dependent (Group I) and non-alcoholic apparently healthy subjects (Group II). **Materials and Methods:** This study was performed in 55 alcoholics and 55 non-alcoholic apparently healthy subjects in the age group of 20-55 years. Muscle strength and endurance were recorded using the handgrip dynamometer in both the groups. Muscle strength readings were denoted as Tmax (kg/sec). Endurance was recorded in seconds for the 30% and 50% of the Tmax values. **Results:** In alcoholics, the Tmax, endurance at T50% and T30% were 22.35$\pm$4.31, 21.64$\pm$14.8 16.33$\pm$8.77 respectively while in the non-alcoholics, Tmax, endurance at T50% and T30% were 29.18$\pm$4.55, 30.25$\pm$8.13 and 23.22$\pm$7.98 respectively. There was a statistically significant difference in the endurance a T30% values, between the groups, the values being lower in alcoholics when compared to the non-alcoholic group. **Conclusion:** Our results suggest that alcohol has a negative impact on muscle strength and endurance as the endurance at T30% of the alcoholics was lower than that of the non-alcoholics. However although statistically significant, the clinical significance of this finding needs to be ascertained and by creating awareness of the adverse effects of alcohol among alcohol dependent individuals, their quality of life can be improved.

Keywords: alcoholics, endurance, muscle strength, Tmax

Corresponding author
Dr. Viji Devanand, Professor & HOD, Department of Physiology, Stanley Medical College (Affiliated to The Tamil Nadu Dr. MGR Medical University), 305 OSH Road, Royapuram, Chennai, Tamil Nadu 600001
Telephone: + 91 98404 95703, Email: devanandviji@gmail.com

Introduction

The World Health Organization (WHO) has published the Sustainable Development Goals (SDGs) for 2030, which was adopted by the United Nations General Assembly in September 2015.[1] Target 3.5 of the SDGs is to strengthen the prevention and treatment of substance abuse, which includes both narcotic drug abuse and harmful use of alcohol.[1] Alcohol dependent subjects have behavioural and mental disorders, and an increased prevalence of cardiovascular disease, attenuated bone health, cancer, physical problems.[2] They are also documented to have an inactive lifestyle which is associated with lifestyle related diseases and premature death, restricted muscle strength and endurance.[2] Alcohol has a deleterious effect in the body; it adversely influences neural function, cardiovascular physiology, metabolism and thermoregulation.[3] Skeletal muscle dysfunction/ myopathy which is common in alcohol dependent subjects occurs in 40 to 60 percent of chronic alcoholics, with the overall prevalence of chronic

alcohol-related myopathy being 10 times more common than the commonest inherited myopathy with 2000 cases per 100,000 people.[3]

Muscle strength is the "ability of a muscle or muscle group to exert force against a resistance" and muscle endurance is the "ability of a muscle or muscle group to repeatedly exert force against a resistance."[4] Alcohol has a detrimental effect on skeletal muscle, and reduced skeletal muscle strength has been recognized as a risk factor for mortality, which is comparable to the increased risk from obesity and hypertension.[5] Reduced muscle strength and endurance due to alcohol witnessed as chronic alcohol induced myopathy occur in 50% of alcohol misusers who have gait disturbances, local pain, cramps and reduced muscle mass upto 30%; decreased muscle endurance has been associated with psychosis and depression, whereas reduced muscular strength has been found to be associated with psychiatric disorders and even suicide.[5] Muscle strength and endurance can be accessed using Isometric hand grip test/ Isometric dynamometry. Muscle wasting is also a well known complication of alcoholism. Isometric dynamometry enables sensitive monitoring of motor deficits. Ethanol can induce changes in muscle function by inhibition of muscle membrane channel pumps , as well as disturbances of protein synthesis and mitochondrial function - the decreased muscular content of energy phosphagens in alcohol dependent subjects contribute to impaired motor function.[6] In addition, accelerated protein degradation and a decreased content of magnesium in striated muscles have been reported.[7,8] Abnormal glycogen deposition in striated muscle also affects muscle strength and endurance.[9] Chronic alcoholic myopathy frequently presents with painless, progressive proximal muscle weakness from weeks to months with rarely associated local muscle atrophy, muscle twitchings and/or tightness. In the early stage the individual has no clinical symptoms, therefore if we employ Isometric handgrip test in them, reduced muscle strength and endurance can be detected as early as possible and by providing rehabilitation therapy, physical incapacitation can be prevented.[10] So early detection of alcoholic myopathy using Isometric hand grip test and treatment of these subjects with counseling, pharmacological drugs and muscle strengthening and endurance training can enhance physical health and improved mental health. Few studies imply alcohol dependent individuals may be at risk for lifestyle related disease, cardiovascular disease and premature death due to their decreased cardio-respiratory and muscular fitness, but there is a clear need for assessment of physical health in these individuals. We hypothesized that alcohol dependent subject would have a reduced muscle strength and muscle endurance compared with an age and sex matched non-alcoholic apparently healthy subjects. Therefore the aim of our study was to compare the muscle strength and endurance between alcoholics who were alcohol dependent and non-alcoholic apparently healthy subjects.

Materials and methods

Our study is a cross sectional-analytical study. The study was done in two groups of population, Group I and Group II, each comprising of 55 subjects who were age and sex matched. Individuals in the age range of 20-55 years were included in the study. Group I included 55 alcoholic individuals diagnosed to have Alcohol Dependence (AD) based on ICD-10 criteria. The ICD-10 includes the following criteria : "(i) tolerance, (ii) withdrawal, (iii) alcohol being used in larger amounts/ longer period, (iv) presence of a persistent desire or unsuccessful efforts to cut down or control alcohol use, (v) a great deal of time spent in activities necessary to obtain alcohol, use alcohol, or recover from its effects, (vi) important social, occupational, or recreational activities being given up because of alcohol use, and (vii)continued alcohol use despite knowledge of having a persistent or recurrent physical or psychological problem that is likely to have been caused or exacerbated by alcohol" [11] and a diagnosis of Alcohol dependence is based on the presence of any three of these criteria within a one-year period.[11]

Group II included 55 non-alcoholic, apparently healthy individuals. Those in the age group of <20 and >55 years, or those with clinical evidence of hand deformities, history of hepatitis or fatty liver disease, history of any other co-morbid medical illness like Diabetes, Hypertension and Cardiovascular disorder, any long term drug intake and smokers were excluded from the study. Institutional ethical committee clearance was obtained for the study. Alcohol dependent subjects fulfilling the ICD-10 criteria were recruited from the Psychiatry outpatient department. Non-alcoholic apparently healthy subjects were recruited from the Master Health Check-up department. Written informed consent was obtained from both the groups.

The test was performed in sitting posture and the dominant hand was used. After 10 minutes of relaxation, demonstration was given by the investigator about the Isometric hand grip exercise test. Subjects were asked to perform Maximum Voluntary Contraction (MVC) by gripping the handgrip dynamometer, as hard as possible for one second. The maximum force exerted was noted in Kg/sec. An average of the three readings was taken as Tmax. After giving rest for 5 minutes, the subjects were asked to perform isometric hand grip exercise at 50% and 30% of their average MVC with their dominant hand, and to sustain it to the point of fatigue. During the test subjects were instructed to breathe normally. 50% and 30% of Tmax was calculated and the endurance i.e. the time in seconds to maintain in the contracted state was noted. The Tmax, endurance at T50%, T30% was compared between alcoholics and non-alcoholics. Statistical analysis was performed using the SPSS, version 20, software program. The data are presented as Mean ± Standard Deviation. The independent student's t test was used to compare differences between the alcohol dependence group and the non-alcoholic group. Results were considered statistically significant if p-value was < 0.05.

Results

This study conducted to compare the muscle strength and endurance between 55 alcoholics and 55 non-alcoholic apparently healthy subjects in the age group of 20-55 years revealed the following results. As shown in Table 1, the endurance at T30% of Group 1 (Alcoholics) was significantly lower than that of Group II (Non-alcoholics).

Table 1: Comparison of the Tmax, endurance at T50% and T30% of alcoholics and non alcoholics

Variable	Group I (Alcoholics)	Group II (Non-alcoholics)	p value
Tmax (Kg/sec)	22.35±4.31	29.18±4.55	0.69
T30% (seconds)	21.64±14.8	30.25±8.13	<0.00*
T50% (seconds)	16.33±8.77	23.22±7.98	0.4

Values expressed as Mean ± Standard Deviation, * p<0.05 considered significant

Discussion

Our study revealed that there was a statistically significant difference between the endurance at T30% of alcoholic subjects who were alcohol dependent when compared to that of non-alcoholic apparently healthy subjects, the values of the alcoholic subjects being lower. Although statistically significant, the clinical significance will also need to be determined to confirm that alcohol has an impact on muscle strength and endurance. Skeletal muscle dysfunction/myopathy is a common complication in alcohol dependence**.** Alcohol causes a dose-dependent noxious effect on the skeletal muscle, which leads to a progressive functional and structural damage to myocytes, with a reduction in lean body mass.[12] Preclinical studies state that alcohol affects both the anabolic and catabolic pathways in the muscle-mass maintenance and an increased pro-inflammatory and oxidative milieu in the skeletal muscle is the contributing factor leading to alcohol induced skeletal muscle dysfunction, also decreased regenerating capacity of the muscle progenitor cells is an additional mechanism contributing to alcohol-induced loss of muscle mass and muscle growth impairment**.**[3]

Alcohol interferes with the process of energy production by the body. In alcohol dependence, due to chronic intake of alcohol whenever alcohol is metabolized or broken down, the liver is unable to produce as much glucose as needed and thereby the performance is affected. It also affects the body fat to muscle mass ratio, as the carbohydrates found in alcohol, are not converted into glucose, but are used to make fatty acids which are stored as fat mainly in the liver.[13]Alcohol by exacerbating insulin secretion in the presence of a high carbohydrate diet induces reactive hypoglycemia. This plays a pivotal role in endurance.[1] Since alcohol has a detrimental effect on glucose metabolism, energy stores necessary for fuel protein synthesis in the muscles, are not readily available.[14,15]

Alcohol has a diuretic effect and due to this effect, produces more urine. The alcohol's diuretic function has been historically well recognized and dates back to 1948. It has been proved in previous studies that each ml of alcohol consumed caused a 10 ml excess of urine production. Thus, chronic intake leads to dehydration.[14] The effect of alcohol on hydration and its diuretic effect, due to the inhibition of anti-diuretic hormone consequently results in decreased work tolerance.[13] Alcohol inhibits calcium transients

into myocyte by inhibiting sarcolemmal calcium channel actions.[16-18] Consequently this will impair excitation-contraction coupling decreasing the strength output. Chemical processes in the muscles are disrupted, which causes impairment of excitation and contraction process. This decreases the strength output.[19] Alcohol in the body triggers the production of a substance in the liver, which has a direct toxic effect on testosterone. Alcohol inhibits absorption of essential nutrients like thiamine, vitamin B_{12}, folic acid and Zinc; Zinc is important for energy metabolic processes and Zinc depletion reduces endurance.[13]

Alcohol primarily impairs protein synthesis. Alcohol upregulates the expression of muscle specific Atrogin-I, E3 ligases; and Muscle-specific RING finger 1(MuRF1). These proteins promote skeletal muscle atrophy and cause decreased activation of the protein synthetic pathway.[20] Also the effect of alcohol on skeletal muscles is caused by a myriad of factors being: The accumulation of acetaldehyde which is a byproduct of alcohol metabolism causes aversive neurological symptoms. Congeners are substances like methanol, histamine and polyphenols produced during alcohol fermentation. They contribute to the reduction of CNS activity.[14] Gene expression perturbations contribute to development of alcoholic myopathy. Ethanol induced alterations in over 400 genes have been detected and the protein profile of the muscle is also affected. Evidences state that oxidative damage is involved in the pathogenesis of alcohol-induced skeletal myopathy.[12,21] Reduced muscle strength has been shown to result in poor bone health, and a lack of sufficient muscular overload, through absence of physical activity or resistance training which will finally cause bone loss.[22] The weakness is also related to malnutrition, which is common in alcoholism.[13] All these abnormalities that have been discussed contribute to the possible muscle impairment that could occur in alcoholics.

Limitations of this study include the small sample size and the fact that we had not studied alcoholics of various degrees. These deficiencies would be rectified in our future studies. Future studies are planned to compare the muscle strength and endurance between alcohol dependent subjects and alcohol abstinent subjects; to correlate creatinine kinase levels with muscle strength and endurance in alcohol dependent subjects and to study Isometric hand grip test in alcohol-induced cirrhotic patients.

Conclusion

Our hypothesis was that alcohol dependent subject would have a lesser muscle strength and muscle endurance compared with age and sex matched non-alcoholic apparently healthy subjects. Our results suggest that alcohol has a negative impact on muscle strength and endurance as there was a statistically significant difference in the endurance at T30% of alcoholics (which was lower) when compared to that of non-alcoholics. However although statistically significant, the clinical significance of this finding needs to be ascertained; early screening of alcoholic subjects using isometric hand grip test can be planned and awareness about the adverse effects of alcohol among alcohol dependent individuals could be created in an attempt to improve their quality of life.

Acknowledgment: Nil

Conflicts of interests: Nil

References

1. World Health Organization. Sustainable development goals. 2015. Available from http://www.who.int/sdg/en/.
2. Flemmen G, Wang E. Impaired aerobic endurance and muscular strength in substance use disorder patients: Implications for health and premature death. Medicine(Baltimore) 2015; 94(44):e1614
3. Simon L, Jolley SE, Molina PE. Alcoholic Myopathy: Pathophysiologic Mechanisms and Clincal Implications. The Journal of the National Institute on Alcohol Abuse and Alcoholism. Current Reviews.2017;38(2)
4. Sharon A, Denise P, Smith L. Exercise physiology for health, fitness and performance. IVth edition. Wolters Kluwer Lippincott Williams & Wilkins. Pg. 556.
5. Ortega FB, Silventoinenk, TyneliusP,et al. Muscle strength in male adolescents and premature death: Cohort study of one million participants. Br Med J 2012; 345: e 7279.
6. Moller P, Bergstrom J, Furst P, Hellstrom K. Muscle biopsy studies in patients with moderate liver cirrhosis with special reference to energy-rich phosphagens and electrolytes. Scand J Gastroenterol 1984;19:267-272.
7. Zoli M, Marchesini G, Dondi C, Bianchi GP, Pisi E. Myofibrillar protein catabolirates in

cirrhotic patients with and without muscle wasting. Clin Sci 1982;62:683-686.
8. Cohen L. Magnesium and liver cirrhosis: a hypothesis. Magnesium 1985;4:1-4.
9. Kruszynska Y, Williams N, Perry M, home P. The relationship between insulin sensitivity and skeletal muscle enzyme activities in hepatic cirrhosis. Hepatology 1988;8:1615-1629.
10. Preedy VR, Adachi J, Ueno Y, Ahmed S, Mantle D, Mullatti N, Rajendram R, Peters TJ. Alcoholic skeletal muscle myopathy: definitions, features, contribution of neuropathy, impact and diagnosis. European Journal of Neurology. 2001; 8(6):677-687.
11. World Health Organization. International Classification of Diseases Tenth Revision, Clinical Modification (ICD-10-CM). Available from:http://www.who.int/classifications/icd/en/index.html.
12. Fernandez – Sola J, Preedy VR, Lang CH, et al. Molecular and cellular events in alcohol-induced muscle disease. Alcoholism: Clinical and Experimental Research 2007; 31(12): 1953-1962.
13. Gulhane TF. Effect of alcohol on athletic performance. International Journal of Applied Research 2015; 1(5):131-133.
14. Vella LD, Cameron-Smith D. Alcohol, Athletic performance and Recovery. Nutrients 2010; 2(8)781-789
15. Kumar V, Atherton P, Smith K, Rennie MJ. Human muscle protein synthesis and breakdown during and after exercise. J Appl Physiol. 2009; 106: 2026-2040.
16. Cofan M, Fernandez-Sola J, Nicholas JM, Poch E, Urbano-Marquez A. Ethanol decreases basal cytosolic-free calcium concentration in cultured skeletal muscle cells. Alcohol Alcohol. 1995;30: 617-621.
17. Nicolas JM, Fernandez-Sola J, Tobias E, Estruch R, Urbano Marquez A. Acute ethanol treatment decreases calcium transients in cultured human myotubes. Alcohol Clin Exp Res. 1998; 22: 1086 -1092.
18. Cofan DR, Nicolas JM, Fernandes-Sola J, Tobias E, Sacanella E, Estruch R, Urbano-Marquez A. Acute ethanol treatment decreases intra-cellular calcium-ion transients in a mouse single skeletal muscle fibres in-vitro. Alcohol & Alcoholism.2000; 35 (2): 134-138.
19. Dinkelman L. Effect of alcohol on athlete performance and recovery. Available from: https://strength.sports.uiowa.edu/article/effect-alcohol-athlete-performance-and-recovery
20. Vary TC, Frost RA, Lang CH. Acute alcohol intoxication increases atrogin-1 and MuRF1 mRNA without increasing proteolysis in skeletal muscles. Am J Physiol Regul Integr Comp Physiol. 2008;294(6):R1777-R1789.
21. Urbano-Marquez A, Fernandez-Sola J. Effects of alcohol on skeletal and cardiac muscle. Muscle and Nerve. 2004; 30(6):689-707.
22. Cussler EC, Lohman TG, Going SB, et al. Weight lifted in strength training predicts bone change in postmenopausal women. Med Sci Sports Exercise 2003: 35:10-17.