Prevalence of metabolic syndrome and metabolic syndrome components in young adults: A pooled analysis☆☆☆

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ABSTRACT

Metabolic syndrome (MetSyn) represents a clustering of different metabolic abnormalities. MetSyn prevalence is present in approximately 25% of all adults with increased prevalence in advanced ages. The presence of one component of MetSyn increases the risk of developing MetSyn later in life and likely represents a high lifetime burden of cardiovascular disease risk. Therefore we pooled data from multiple studies to establish the prevalence of MetSyn and MetSyn component prevalence across a broad range of ethnicities. PubMed, SCOPUS and Medline databases were searched to find papers presenting MetSyn and MetSyn component data for 18–30 year olds who were apparently healthy, free of disease, and MetSyn was assessed using either the harmonized, National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATPIII), American Heart Association/National Heart, Blood and Lung Institute (AHA/NHBLI), or International Diabetes Federation (IDF) definitions of MetSyn. After reviewing returned articles, 26,609 participants’ data from 34 studies were included in the analysis and the data were pooled. MetSyn was present in 4.8–7% of young adults. Atherogenic dyslipidaemia defined as low high density lipoprotein (HDL) cholesterol was the most prevalent MetSyn component (26.9–41.2%), followed by elevated blood pressure (16.6–26.6%), abdominal obesity (6.8–23.6%), atherogenic dyslipidaemia defined as raised triglycerides (8.6–15.6%), and raised fasting glucose (2.8–15.4%). These findings highlight that MetSyn is prevalent in young adults. Establishing the reason why low HDL is the most prevalent component may represent an important step in promoting primary prevention of MetSyn and reducing the incidence of subsequent clinical disease.

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1. Introduction

MetSyn is an asymptomatic, pathophysiological state characterised by obesity, insulin resistance, hypertension, dysglycaemia, and dyslipidaemia (Alberti et al., 2009). While several criteria and definitions have been used to identify MetSyn (Alberti et al., 2009; Grundy et al., 2005; Alberti et al., 2005; Anon, 2001); it is generally agreed that a combination of three or more of the following components must be present: large waist circumference, elevated triglycerides, low HDL-cholesterol, raised blood pressure, and elevated fasting blood glucose.

The International Diabetes Federation (IDF) estimates that ≈25% of the world’s population has MetSyn (O’Neill and O’Driscoll, 2015) although this estimate varies widely due to the age, ethnicity, and gender of the population studied (Kaur, 2014). Having a slightly raised value of a MetSyn component at a younger age increases the future risk for MetSyn later in life (Gündogan et al., 2009). Therefore it is important to establish the prevalence of MetSyn components in young adults (18–30 years), as the presence of a MetSyn component could represent a lifetime of increased cardiovascular disease risk. Moreover, the early identification of MetSyn components could lead to targeted interventions to prevent the development of the syndrome, and thus reduce cardiovascular disease risk in later life.

Therefore, we performed a pooled analysis of previous literature that examined the prevalence of MetSyn and components of MetSyn in young adults with the purpose of determining: 1) the global prevalence of MetSyn in young adults, and 2) the most prevalent MetSyn component in this population.

2. Methods

PubMed, SCOPUS and Medline were searched using the terms “Metabolic Syndrome”, “Prevalence”, and “Young Adults” combined with the Boolean operator “AND”. The search was repeated using the term “College Students” instead of “Young Adults” and the results combined.
Duplicates from the returned reference lists were discarded and the list was consolidated into one list from the three databases.

Abstracts from the returned references were downloaded and were kept if the abstract indicated that the article may contain data relating to MetSyn and apparently healthy young adults. The remaining articles were downloaded in full and analysed for specific data relating to MetSyn in young adults. Studies were included if 1) Participants were sampled on the basis of being apparently healthy, free of chronic conditions, or having specific anthropometric characteristics; 2) Data were available in the age range of 18–30 years old; 3) The prevalence for MetSyn was supplied or able to be calculated; 4) The NCEP-ATPIII criteria (Anon, 2001), Revised NCEP-ATPIII (referred to here as AHA/NHBLL) criteria (Grundy et al., 2005), International IDF criteria (Alberti et al., 2005) or the harmonized criteria (Alberti et al., 2009) for MetSyn were used (Table 1). In addition, the article had to be written in English and accessible either through open access or our institution's library subscription that has access to 1200+ databases and 98,000 e-journals. All papers were cross checked to ensure that data were not used across multiple studies.

Data relating to MetSyn and MetSyn components in 18–30 year old adults were extracted from the reviewed articles and MetSyn and MetSyn component prevalence was calculated using the four different definitions. The results were tabulated (Table 2).

3. Results

From the initial search, 1276 unique citations were returned, of which 992 studies were immediately discarded based on the title or abstract. The remaining 284 studies were evaluated against the inclusion criteria. Thirty-four papers were included in the final review with 11 studies (Bener et al., 2010; da Silveira et al., 2010; Cavrila et al., 2011; Gundogan et al., 2009; Hildrum et al., 2007; Huang et al., 2007; Li et al., 2010; Martins et al., 2015; Mikkola et al., 2007; Sy et al., 2014; Tope et al., 2013) providing MetSyn data based on multiple definitions. Data from 26,609 different people aged between 18 and 30 years from 17 countries were available for analysis – see table for individual and group prevalence data. Please note that the combined number of observations for all MetSyn definitions is >26,609 due to the inclusion of studies using multiple definitions.

Overall MetSyn prevalence was 4.8% (NCEP-ATPIII, n = 333/6889) 5.2% (AHA/NHBLL, n = 643/12473), 7.0% (IDF, n = 971/13953) and 6.5% (harmonized, n = 430/6578). Otherogenic dyslipidaemia defined as low HDL was the most prevalent MetSyn component regardless of the criteria used (26.9–41.2%) followed by raised blood pressure (16.6–26.6%), abdominal obesity (6.8–23.6%), otherogenic dyslipidaemia defined as raised triglycerides (8.6–15.6%), and raised fasting glucose (2.8–15.4%) (Fig. 1).

4. Discussion

This study provides new information about MetSyn in young adults in two important ways. First, pooled analysis of a large sample suggests that 5–7% of young adults have MetSyn. While the prevalence is less than the ID estimated prevalence in all adults of 25% worldwide (O’Neill and O’Driscoll, 2015), the development of MetSyn early in adulthood can lead to an elevated lifetime burden of cardiovascular disease risk. Second, one third of all participants had at least one component of MetSyn with low HDL being the most prevalent component. This latter finding raises the possibility that low HDL may be a key marker identifying early pathology associated with the development of MetSyn.

Prevention of the development of the first MetSyn component may have significant public health benefits as the presence of one component is predictive of the development of MetSyn (Cheung et al., 2008). Low HDL cholesterol occurs primarily due to increased triglyceride formation reducing cholesterol content of the lipoprotein core (Eckel et al., 2004). Accordingly, it was expected that a higher prevalence of raised triglyceride levels would be observed in the current findings; however, this did not occur. We speculate that this could reflect currently unknown mechanisms regarding HDL metabolism or a triglyceride cut-off point not calibrated to changes in HDL levels in young adults. Regardless, while low HDL is not universally exhibited in all young adults with at least one MetSyn component, our findings demonstrate that low HDL is the most frequently exhibited MetSyn component regardless of MetSyn definition and may indicate the initiation of pathophysiological processes that underpin the development of MetSyn for many young adults. Further research should be undertaken to identify why low-HDL is the most common component of MetSyn in young adults.

MetSyn component prevalence was lower than reported for European adults from a more diverse and older aged population than the current study (Vishram et al., 2014). Approximately 45% of 19–39 year old adults had the BP component, 25% the WC component, 25% TG component, and 20% with HDL component of MetSyn (Vishram et al., 2014). Vishram et al. also report an increased prevalence of BP and WC in males with increased age with a peak prevalence of elevated TGs and reduced HDL in the 40–49 year age bracket with a subsequent decline in older age ranges (50–59, 60–78 years). A similar pattern was observed in

Table 1

| MetSyn Criteria | Harmonized | IDF | NCEP-ATPIII | AHA/NHBLL |
|-----------------|------------|-----|-------------|-----------|
| Any three or more of: | WC ≥ 94 cm (male) | WC ≥ 80 cm (female) | ≥ 102 cm (male) | ≥ 102 cm (male) |
| WC | Ethnic specific cut points | And two or more of: | ≥ 88 cm (female) | ≥ 88 cm (female) |
| HDL | < 1.03 mmol/L (male) | < 1.03 mmol/L (male) | < 1.03 mmol/L (male) | < 1.03 mmol/L (female) |
| OR taking medication for reduced HDL | < 1.29 mmol/L (female) | < 1.29 mmol/L (female) | < 1.29 mmol/L (female) | < 1.29 mmol/L (female) |
| TG | ≥ 1.7 mmol/L or medication for elevated TG | ≥ 1.7 mmol/L or medication for elevated TG | ≥ 1.7 mmol/L or medication for elevated TG | ≥ 1.7 mmol/L or medication for elevated TG |
| BP | ≥ 130 mm Hg Systolic BP or ≥ 85 mm Hg Diastolic BP or on BP-lowering medication | ≥ 130 mm Hg Systolic BP or ≥ 85 mm Hg Diastolic BP or on BP-lowering medication | ≥ 130 mm Hg Systolic BP or ≥ 85 mm Hg Diastolic BP or on BP-lowering medication | ≥ 130 mm Hg Systolic BP or ≥ 85 mm Hg Diastolic BP or on BP-lowering medication |
| FPG | ≥ 5.6 mmol/L or antidiabetic medication | ≥ 5.6 mmol/L or antidiabetic medication | ≥ 5.6 mmol/L or antidiabetic medication | ≥ 5.6 mmol/L or antidiabetic medication |

MetSyn – metabolic syndrome; WC – abdominal obesity; HDL – otherogenic dyslipidaemia (low HDL); TG – otherogenic dyslipidaemia (raised triglycerides); BP – raised blood pressure; FPG – raised fasting glucose.
females except TG prevalence increased with age and only HDL prevalence is decreased in ages above 40–49 years. Therefore, prevalence of MetSyn components in young adults is expected to increase up to the age of 50.

While overall MetSyn prevalence was similar between the four MetSyn definitions, a wide range of prevalence was present for each MetSyn component. Differences in WC prevalence can be partially explained by the use of ethnic specific thresholds for each MetSyn component. Therefore, possibilities worth exploring is that all MetSyn component thresholds may be ethnic specific and thus specific ethnic thresholds for each MetSyn component may need to be developed to accurately assess MetSyn. This is similar to current recommendations of using ethnic specific thresholds for WC.

5. Conclusion

MetSyn prevalence ranges from 5 to 7% in young adults. Low HDL is the most prevalent component of MetSyn in young adults and thus may be the first detectable component of MetSyn in many young adults. Exploring the importance and significance of low HDL in young adults may have considerable public health benefit as interventions aimed at improving low HDL cholesterol levels could reduce future incidence of MetSyn and consequent clinical disease.
Fig. 1. Prevalence of metabolic syndrome and metabolic syndrome components in 26,609 young adults according to four metabolic syndrome criteria. MetSyn – metabolic syndrome; WC – abdominal obesity; HDL - atherogenic dyslipidemia (low HDL); TG - atherogenic dyslipidemia (raised triglycerides); BP - raised blood pressure; FBG – raised fasting glucose.

References

Al Dhaheri, A.S., Mohamad, M.N., Jarrar, A.H., et al., 2016. In: Ahmad, R. (Ed.), A Cross-Sectional Study of the Prevalence of Metabolic Syndrome among Young Female Emirati Adults. PLoS One 11 (7), e0159378. http://dx.doi.org/10.1371/journal.pone.0159378.

Alberti, K.G.M.M., Zimmet, P., Shaw, J., et al., 2005. The metabolic syndrome—a new worldwide definition. Lancet 366 (9491):1059–1062. http://dx.doi.org/10.1016/S0140-6736(05)67402-8.

Alberti, K.G., Eckel, R.H., Grundy, S.M., et al., 2009. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention, National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International. Circulation 120 (16): 1640–1645. http://dx.doi.org/10.1161/CIRCULATIONAHA.109.192644.

Anon, 2001. Expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (adult treatment panel III). Executive summary of the third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (adult treatment panel III). JAMA. J. Am. Med. Assoc. 285 (19):2486–2497. http://dx.doi.org/10.1001/jama.285.19.2486.

Bener, A., Zirie, M., Musallam, M., Khader, Y., Al-Hamag, A.O.A. a a, 2009. Prevalence of metabolic syndrome according to Adult Treatment Panel III and International Diabetes Federation criteria: a population-based study. Metab. Syndr. Relat. Disord. 7 (3): 221–229. http://dx.doi.org/10.1089/met.2008.0077.

Bener, A., Mohammad, A.G., Ismail, A.N., Zirie, M., Abdullah, W.K., Al-Hamag, A.O.A., 2010. Gender and age-related differences in patients with the metabolic syndrome in a highly endogamous population. Bosn. J. Basic Med. Sci. 10 (3):210–217. http://dx.doi.org/10.1590/S0066-782X2010005000113.

Bennett, N.R., Ferguson, T.S., Bennett, F.I., et al., 2014. High-sensitivity C-reactive protein is related to central obesity and the number of metabolic syndrome components in Jamaican young adults. Front Cardiovasc Med. 1. http://dx.doi.org/10.3389/fcvm.2014.00012.

Chekir, M.J., Wu, G.-R., Shen, L.-Y., Shi, Y.-H., Le, G.-W., 2014. Disparities in the prevalence of metabolic syndrome and its components among university employees by age, gender and occupation. J. Clin. Diagn. Res. 8 (2):65–69. http://dx.doi.org/10.1006/jcrs.2014.05.010.

Cheung, B.M.Y., Wat, N.M.S., Tam, S., et al., 2008. Components of the metabolic syndrome predictive of its development: a 6-year longitudinal study in Hong Kong Chinese. Clin. Endocrinol. 68 (5):730–737. http://dx.doi.org/10.1111/j.1365-2265.2007.03110.x.

Costa, F.F. da, Montenegro, V.B., Lopes, T.J.A., Costa, E.C., 2011. Combinación de fatores de risco relacionados à síndrome metabólica em militares da Marinha do Brasil. Arq. Bras. Cardiol. 97 (6):485–492. http://dx.doi.org/10.1590/S0006-782X2011000600113.

Dalleck, L.C., Kjelland, E.M., 2012. The prevalence of metabolic syndrome and metabolic syndrome risk factors in college-aged students. Am. J. Health Promot. 27 (1). http://dx.doi.org/10.4278/ajhp.100415-QUAN-116.

Eckel, R.H., Grundy, S.M., Zimmet, P.Z., et al., 2004. The metabolic syndrome. Lancet 365 (9488):1415–1420. http://dx.doi.org/10.1016/S0140-6736(05)68378-7.

Erem, C., Hacihosangolu, A., Deger, O., et al., 2008. Prevalence of metabolic syndrome and associated risk factors among Turkish adults: Trabzon MetS study. Endocrine 33 (1): 9–20. http://dx.doi.org/10.1007/s12020-008-9044-3.

Ferguson, T.S., Tulloch-Reid, M.K., Younger, N.O., et al., 2010. Prevalence of the metabolic syndrome and its components in relation to socioeconomic status among Jamaican young adults: a cross-sectional study. BMC Public Health 10 (1):307. http://dx.doi.org/10.1186/1471-2458-10-307.

Fernandes, J., Lofgren, I., 2011. Prevalence of metabolic syndrome and individual criteria in college students. J. Am. Coll. Heal. 59 (4):313–321. http://dx.doi.org/10.1080/07378722.2010.508084.

Gavila, D., Salmerón, D., Egea-Caparrós, J.M., et al., 2011. Prevalence of metabolic syndrome in Murcia Region, a southern European Mediterranean area with low cardiovascular risk and high obesity. BMC Public Health 11 (1):562. http://dx.doi.org/10.1186/1471-2458-11-562.

Grundy, S.M., Cleeman, J.I., Daniels, S.R., et al., 2005. Diagnosis and management of the metabolic syndrome. Circulation 112 (17).

Gündogar, K., Bayram, F., Casap, M., et al., 2009. Prevalence of metabolic syndrome in the Mediterranean region of Turkey: evaluation of hypertension, diabetes mellitus, obesity, and dyslipidemia. Metab. Syndr. Relat. Disord. 7 (5):427–434. http://dx.doi.org/10.1089/met.2008.0058.

Gupta, R., Misra, A., Vikram, N.K., et al., 2009. Younger age of escalation of cardiovascular risk factors in Asian Indian subjects. BMC Cardiovasc. Disord. 9. http://dx.doi.org/10.1186/1471-2258-9-28.

Hildrum, B., Mykletun, A., Hole, T., et al., 2007. Age-specific prevalence of the metabolic syndrome defined by the International Diabetes Federation and the National Cholesterol Education Program: the NORWEGIAN HUNT 2 study. BMC Public Health 7 (1):220. http://dx.doi.org/10.1186/1471-2458-7-220.

Huang, T.T.-K., Kerei, T.M., Strother, M.L., et al., 2004. Overweight and components of the metabolic syndrome in college students. Diabetes Care 27 (12):3000–3001. http://dx.doi.org/10.2337/diacare.27.12.3000.

Huang, T.T.-K., Shimeal, A., Lee, R.E., Delaney, W., Strother, M.L., 2007. Metabolic risks among college students: prevalence and gender differences. Metab. Syndr. Relat. Disord. 5 (4):365–372. http://dx.doi.org/10.1089/met.2007.0021.

Huang, C.-Y., Chang, H.-H., Lu, C.-W., Tseng, F.-Y., Lee, L.-T., Huang, K.-C., 2015. Vitamin D status and risk of metabolic syndrome among non-diabetic young adults. Clin. Nutr. 34 (3):484–489. http://dx.doi.org/10.1016/j.clnu.2014.05.010.

Kaduka, L.U., Kombe, Y., Kenya, E., et al., 2012. Prevalence of metabolic syndrome among non-diabetic young adults: a cross-sectional study in a highly endogamous population. Bosn. J. Basic Med. Sci. 10 (3):210-217. http://dx.doi.org/10.3389/fcvm.2014.00012.

Kaur, J., 2014. A comprehensive review on metabolic syndrome. Cardiol. Res. Pract. 2014:1–9. http://dx.doi.org/10.1155/2014/943162.

de Kroon, M.L. a, Renders, C.M., Kuipers, E.C.C., et al., 2008. Identifying metabolic syndrome without blood tests in young adults—the Teneuzern Birth Cohort. Eur. J. Publ. Health 18 (6):656–660. http://dx.doi.org/10.1093/eurpub/ckn056.
Li, G., de Courten, M., Jiao, S., Wang, Y., 2010. Prevalence and characteristics of the metabolic syndrome among adults in Beijing, China. Asia Pac. J. Clin. Nutr. 19 (1):98–102. http://www.scopus.com/inward/record.url?eid=2-s2.0-77552316082&partnerID=40&md5=c3cc0b6c5c6dc166de8b35sa517f6ed.

Lin, K.P., Liang, T.L., Liao, I.C., Tsay, S.L., 2014. Associations among depression, obesity, and metabolic syndrome in young adult females. Biol. Res. Nurs. 16 (3):327–334. http://dx.doi.org/10.1177/1099800413500138.

Manjunath, D., Uthappa, C.K., Kattula, S.R., Allam, R.R., Chava, N., Oruganti, G., 2014. Metabolic syndrome among urban Indian young adults: prevalence and associated risk factors. Metab. Syndr. Relat. Disord. 12 (7):381–389. http://dx.doi.org/10.1089/met.2014.0003.

Martins, M.L.B., Kac, G., Silva, R.A., et al., 2015. Dairy consumption is associated with a lower prevalence of metabolic syndrome among young adults from Ribeirão Preto, Brazil. Nutrition 31 (5):716–721. http://dx.doi.org/10.1016/j.nut.2006.09.019.

Mikkola, I., Keinänen-Kiukaanniemi, S., Laakso, M., et al., 2007. Metabolic syndrome in connection with BMI in young Finnish male adults. Diabetes Res. Clin. Pract. 76 (3):404–409. http://dx.doi.org/10.1016/j.diabres.2006.09.019.

Morrell, J.S., Lofgren, I.E., Burke, J.D., Reilly, R.A., 2012. Metabolic syndrome, obesity, and related risk factors among college men and women. J. Am. Coll. Heal. 60 (1):82–89. http://dx.doi.org/10.1080/07448481.2011.582208.

Morrell, J.S., Cook, S.B., Carey, G.B., 2013. Cardiovascular fitness, activity, and metabolic syndrome among college men and women. Metab. Syndr. Relat. Disord. 11 (5):370–376. http://dx.doi.org/10.1089/met.2013.0011.

O'Neill, S., O'Driscoll, L., 2013. Metabolic syndrome: a closer look at the growing epidemic and its associated pathologies. Obes. Rev. 16 (1):1–12. http://dx.doi.org/10.1111/obr.12229.

Shahbazian, H., Latifi, S.M., Jalali, M.T., et al., 2013. Metabolic syndrome and its correlated factors in an urban population in South West of Iran. J. Diabetes Metab. Disord. 12 (1). http://dx.doi.org/10.11186/2291-6581-12-11.

Sharifi, F., Mousaviniasab, S.N., Saeini, M., Dimnohmammadi, M., 2009. Prevalence of metabolic syndrome in an adult urban population of the west of Iran. Exp. Diabetes Res. 2009:136501. http://www.scopus.com/inward/record.url?eid=2-s2.0-74049095614&partnerID=40&md5=f9a269443ba0d45e2c2d5b7e8244cd.

Sidorenkov, O., Nilsson, O., Brenn, T., Martinusov, S., Arhipovsky, V.I., Grjibovski, A.M., 2010. Prevalence of the metabolic syndrome and its components in Northwest Russia: the Arkhangelsk study. BMC Public Health 10. http://dx.doi.org/10.1186/1471-2458-10-23.