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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.

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.

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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-ATP III criteria (Anon, 2001), Revised NCEP-ATPIII (referred to here as AHA/NHBLI) 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; Gavrila et al., 2011; Gündogan 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 grouped 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/NHBLI, $n = 643/12473$), 7.0% (IDF, $n = 971/13953$) and 6.5% (harmonized, $n = 430/6578$). Atherogenic 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%), atherogenic 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 IDF 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 pathphysiological 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
Metabolic syndrome criteria according to Harmonized (Alberti et al., 2009), IDF (Alberti et al., 2005), NCEP-ATPII (Anon, 2001) and AHA/NHBLI criteria (Grundy et al., 2005).

MetSyn Criteria	Harmonized	IDF	NCEP-ATPIII	AHA/NHBLI
	Any three or more of:	WC ≥ 94 cm (male) WC ≥ 80 cm (female)	Any three or more of:	Any three or more of:
WC	Ethnic specific cut points	And two or more of:	≥102 cm (male) ≥88 cm (female)	≥102 cm (male) ≥88 cm (female)
HDL	<1.03 mmol/L (male) <1.29 mmol/L (female) OR taking medication for reduced HDL	<1.03 mmol/L (male) <1.29 mmol/L (female) OR taking medication for reduced HDL	<1.03 mmol/L (male) <1.29 mmol/L (female) OR taking medication for reduced HDL	<1.03 mmol/L (male) <1.29 mmol/L (female) OR taking medication for reduced HDL
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
FBG	≥5.6 mmol/L or antidiabetic medication	≥5.6 mmol/L or antidiabetic medication	≥6.1 mmol/L or antidiabetic medication	≥5.6 mmol/L or antidiabetic medication

MetSyn – metabolic syndrome; WC – abdominal obesity; HDL - atherogenic dyslipidaemia (low HDL); TG - atherogenic dyslipidaemia (raised triglycerides); BP - raised blood pressure; FBG – raised fasting glucose.

Table 2
Prevalence of metabolic syndrome and metabolic syndrome components in 26,609 young adults.

	Author	Country	Total (n)	MetSyn	WC	HDL	TG	BP	FBG
Harmonized	Al Dhaheri et al. (2016)	UAE	555	38 (6.8)	101 (18.2)	271 (48.8)	8 (1.4)	30 (5.4)	54 (9.7)
	Bennett et al. (2014)	Jamaica	746	6 (0.8)	108 (14.5)	343 (46.0)	4 (0.5)	154 (20.6)	8 (1.1)
	Ferguson et al. (2010)	Jamaica	839	10 (1.2)	134 (16.0)	393 (46.8)	5 (0.6)	56 (6.7)	10 (1.2)
	Gavrila et al. (2011)[a]	Spain	292	18 (6.2)	81 (27.7)	49 (16.8)	24 (8.2)	48 (16.4)	11 (3.8)
	Gupta et al. (2009)	India	486	12(2.5)	51 (10.5)	150 (30.9)	27 (5.6)	15 (3.1)	31 (6.4)
	Huang et al. (2015)	Taiwan	355	24 (6.8)	63 (17.7)	46 (20.6)	32 (9.0)	123 (34.6)	4 (1.1)
	Kaduka et al. (2012)	Kenya	90	9 (10.0)	17 (18.9)	47 (52.2)	3 (3.3)	51 (56.7)	1 (1.1)
	Lin et al. (2014)	China	323	22 (6.8)	180 (55.7)	63 (19.5)	40 (12.4)	20 (6.2)	22 (6.8)
	Martins et al. (2015)[a]	Brazil	2031	242 (9.0)	646 (31.8)	851 (41.9)	254 (12.5)	465 (22.9)	73 (3.6)
	Sy et al. (2014)[a]	Philippines	861	108 (12.5)	173 (20.1)	467 (54.2)	171 (19.9)	127 (14.8)	144 (16.7)
	Overall		6578	430 (6.5%)	1554 (23.6%)	2707 (41.2%)	568 (8.6%)	1089 (16.6%)	358 (5.4%)
NCEP –ATPIII	Erem et al. (2008)	Turkey	1306	93 (7.1)	182 (13.9)	318 (21.3)	183 (14.0)	424 (32.5)	25 (1.9)
	Gündogan et al. (2009)[a]	Turkey	84	10 (11.9)	25 (29.8)	19 (22.6)	24 (28.6)	20 (23.8)	11 (13.1)
	Huang et al. (2004)	USA	163	1 (0.6)	3 (1.8)	22 (13.5)	4 (2.5)	2 (1.2)	3 (1.8)
	Li et al. (2010)[a]	China	2532	101 (4.0)	79 (3.1)	742 (29.3)	241 (9.5)	519 (20.5)	58 (2.3)
	Manjunath et al. (2014)	India	473	41 (8.7)	76 (16.1)	184 (38.9)	37 (7.8)	123 (26.0)	42 (8.9)
	Mikkola et al. (2007)[a]	Finland	1099	38 (3.5)	51 (4.6)	212 (19.3)	31 (2.8)	565 (51.4)	25 (2.3)
	Sidorenkov et al. (2010)	Russia	862	23 (2.7)	19 (2.2)	266 (30.9)	83 (9.6)	149 (17.3)	6 (0.7)
	Sinha et al. (2013)	India	85	8 (9.4)	18 (21.2)	53 (62.4)	18 (21.2)	5 (5.9)	7 (8.2)
	Soysal et al. (2005)	Turkey	285	18 (6.3)	14 (4.9)	40 (14.0)	115 (40.4)	25 (8.8)	13 (4.6)
	Overall		6889	333 (4.8%)	467 (6.8%)	1856 (26.9%)	736 (10.7%)	1832 (26.6%)	190 (2.8%)
IDF	Bener et al. (2009)[a]	Qatar	203	16 (7.9)	16 (7.9)	43 (21.2)	30 (14.8)	34 (16.7)	8 (3.9)
	da Costa et al. (2011)	Brazil	711	28 (3.9)	90 (12.7)	313 (44.0)	35 (4.9)	71 (10.0)	35 (1.4)
	da Silveira et al. (2010)[a]	Brazil	3599	240 (6.7)	618 (17.2)	694 (19.3)	598 (16.6)	883 (24.5)	1322 (36.7)
	Gavrila et al. (2011)[a]	Spain	292	18 (6.2)	81 (27.7)	49 (16.8)	24 (8.2)	48 (16.4)	11 (3.8)
	Gündogan et al. (2009)[a]	Turkey	84	16 (19.0)	25 (29.8)	19 (22.6)	24 (28.6)	20 (23.8)	11 (13.1)
	Hildrum et al. (2007)[a]	Norway	1615	19 (1.2)	414 (25.6)	459 (28.4)	221 (13.7)	499 (30.9)	179 (11.1)
	Huang et al. (2007)[a]	USA	300	2 (0.7)	8 (2.7)	73 (24.3)	27 (9.0)	11 (3.7)	27 (9.0)
	Kanitkar et al. (2015)	India	250	55 (22.0)	139 (55.6)	93 (37.2)	71 (29.2)	21 (8.4)	44 (17.6)
	Li et al. (2010)[a]	China	2532	147 (5.8)	79 (3.1)	742 (29.3)	241 (9.5)	519 (20.5)	58 (2.3)
	Martins et al. (2015)[a]	Brazil	2031	242 (11.9)	646 (31.8)	851 (41.9)	254 (12.5)	465 (22.9)	73 (3.6)
	Mikkola et al. (2007)[a]	Finland	1099	75 (6.8)	134 (12.2)	212 (19.3)	31 (2.8)	565 (51.4)	221 (20.1)
	Sy et al. (2014)[a]	Philippines	861	108 (9.1)	173 (20.1)	467 (54.2)	171 (19.9)	127 (14.8)	144 (16.7)
	Tope et al. (2013)[a]	USA	376	35 (9.3)	43 (11.4)	73 (19.4)	21 (5.6)	38 (10.1)	42(11.2)
	Overall		13,953	971 (7.0%)	2466 (17.7%)	4088 (29.3%)	1750 (12.5%)	3301 (23.7%)	2150 (15.4%)
AHA/NHBLI	Bener et al. (2009)[a]	Qatar	203	15 (7.4)	16 (7.9)	43 (21.2)	30 (14.8)	34 (16.7)	8 (3.9)
	Cheserek et al. (2014)	China	200	1 (0.5)	4 (2.0)	19 (9.5)	13 (6.5)	24 (12.0)	6 (3.0)
	da Silveira et al. (2010)[a]	Brazil	3599	213 (5.9)	269 (7.5)	694 (19.3)	598 (16.6)	883 (24.5)	610 (16.9)
	Dalleck and Kjelland (2012)	USA	207	14 (6.8)	12 (5.8)	98 (47.3)	28 (13.5)	34 (16.4)	15 (7.2)
	de Kroon et al. (2008)	Netherlands	642	48 (7.5)	78 (12.1)	187 (29.1)	50 (7.8)	274 (42.7)	75 (11.7)
	Fernandes and Lofgren (2011)	USA	189	7 (3.7)	14 (7.4)	38 (20.1)	33 (17.5)	4 (2.1)	14 (7.4)
	Gavrila et al. (2011)[a]	Spain	292	10 (3.4)	31 (10.6)	49 (16.8)	24 (8.2)	48 (16.4)	11 (3.8)
	Hildrum et al. (2007)[a]	Norway	1615	19 (1.2)	414 (25.6)	459 (28.4)	221 (13.7)	499 (30.9)	179 (11.1)
	Huang et al. (2007)[a]	USA	300	4 (1.3)	8 (2.7)	73 (24.3)	27 (9.0)	11 (3.7)	27 (9.0)
	Morrell et al. (2013)	USA	1610	81 (5.0)	209 (130)	467 (29.0)	258 (16.0)	403 (25.0)	64 (4.0)
	Morrell et al. (2012)	USA	2103	103 (4.9)	94 (4.5)	538 (25.6)	350 (16.6)	681 (32.4)	177 (8.4)
	Shahbazian et al. (2013)	Iran	203	13 (6.4)	26 (12.8)	85 (41.9)	47 (23.2)	1 (0.5)	35 (17.2)
	Sharifi et al. (2009)	Iran	934	70 (7.5)	31 (9.7)	714 (76.4)	246 (26.3)	56 (6.0)	74 (7.9)
	Tope et al. (2013)[a]	USA	376	45 (12.0)	43 (11.4)	73 (19.4)	21 (5.6)	38 (10.1)	42 (11.2)
	Overall		12,473	643 (5.2%)	1309 (10.5%)	3537 (28.4%)	1946 (15.6%)	2990 (24.0%)	1337 (10.7%)

Data are expressed as n (%).
MetSyn – metabolic syndrome; WC – abdominal obesity; HDL - atherogenic dyslipidaemia (low HDL); TG - atherogenic dyslipidaemia (raised triglycerides); BP - raised blood pressure; FBG – raised fasting glucose.
[a] Indicates study used more than one definition of MetSyn and is included multiple times.

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 in the harmonized and IDF definitions but the difference in HDL, BP, and FBG prevalence, cannot be explained by the definition. Therefore, it is possible that these observations indicate young adults from different ethnicities are more prone to develop different components of MetSyn. Therefore, a possibility 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 also 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 subsequent clinical disease.

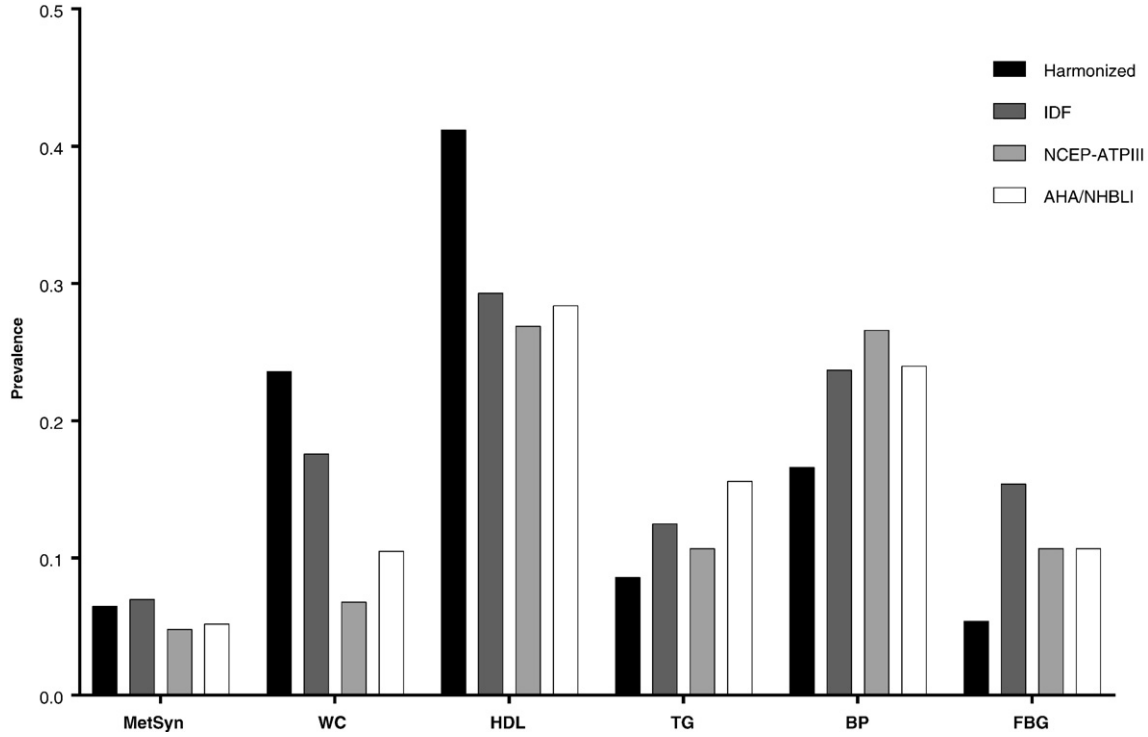

Fig. 1. Prevalence of metabolic syndrome and metabolic syndrome components in 26,609 young adults according to four metabolic syndrome criteria. MetSyn – metabolic syndrome; WC – abdominal obesity; HDL - atherogenic dyslipidaemia (low HDL); TG - atherogenic dyslipidaemia (raised triglycerides); BP - raised blood pressure; FBG – raised fasting glucose.

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