Poster Exhibition

3. Epidemiology of Obesity and Metabolic Syndrome

Gestational Weight Gain in Mongolian Women: Multicenter, cohort study

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Background: Obesity and overweight rates are increasing in all age groups globally, especially in low- and middle-income countries.The study aimed to assess gestational weight gain according to the Institute of Medicine recommendations for each pre-pregnancy body mass index in Mongolian women.

Methods: We conducted a multicenter, prospective cohort study among pregnant women who attended antenatal care in health centers in two districts of Ulaanbaatar, from February 21 to March 25, 2022. The study of ethics was approved at a meeting of the Ethics Committee of the Mongolian National University of Medical Sciences (2022/3-02). Structured questionnaires and physical measurements were performed during pregnancy. Moreover, we obtained data from women's medical records after giving birth. Pre-pregnancy BMI was classified as underweight (<18.5 kg/m2), normal (18.5-24.9kg/m2), overweight (25.0-29.9 kg/m2), and obese (≥30 kg/m2). Gestational weight gain was categorized as inadequate, adequate, and excessive based on the United States Institute of Medicine criteria (IOM).

Results: A total of 468 pregnant women were enrolled in the study. Gestational weight gain (GWG) was assessed for 352 (75.2%) women. The mean age was 30.34±6.02 (18-46 years). According to pre-pregnancy BMI, 9.1% (n=32), 59.1% (n=208), 23.3% (n=82), and 8.5% (n=30) of women were underweight, normal weight, overweight and obese, respectively. The mean GWG was 17.17±6.38 kg for underweight, 15.08±7.36 kg for normal weight, 11.75±6.29 kg for overweight, and 9.05±6.37 kg for obese women (p<0.001). Adequate GWG occurred in 46.9%, 23.1%, 32.9%, and 33.3% of the groups. More than the recommended GWG (excessive) occurred in 37.5%, 40.9%, 46.3%, and 43.3% of underweight, normal weight, overweight and obese women respectively. Only 28.4% (n=100) of women had adequate gestational weight gain during pregnancy.

Conclusion: This study found that despite the lower mean GWG of overweight and obese women gained more than the IOM recommendations for GWG. Furthermore, healthcare professionals should advise appropriate weight gain during pregnancy at antenatal visits.

Comparison of Metabolic Syndrome in Indonesian and South Korean Populations: Results for National Health Surveys

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Background: Metabolic syndrome (MetS) elevates the risk of cardiometabolic diseases and mortality. Its prevalence is rising, particularly in the Asia-Pacific region. Asians, who constitute over 60% of the global population, face higher cardiometabolic risk at equivalent BMI levels compared to Caucasians. Therefore, a large data study on the Asian population considering country-specific differences is necessary. This study compares the prevalence of MetS and its components between Indonesia and South Korea.

Methods: Participants aged 19 and older were included from the 2018 Indonesian Basic Health Survey (RISKESDAS) and the 2018 Korean National and Nutrition Health Examination Survey (KNHANES). MetS was defined according to the Joint Interim Statement criteria, requiring at least three out of five cardiometabolic abnormalities. The participants were stratified by sex and age, with cut-offs at 30 and 50 years (young adults: <30 years old; middle-aged adults: 30-50 years old; and older adults: 50 years old). Data were analyzed separately for each country and weighted to correct for differences in geographical density.

Results: The study included 23,045 participants (45,6% men and 54,4% women) from RISKESDAS and 5,950 participants (50,3% men and 49,7% women) from KNHANES. The overall prevalence of MetS was similar in both countries (33.3% in Indonesia vs. 32.9% in South Korea). However, Indonesian men had a lower MetS prevalence than South Korean men (25.4% vs. 34.7%), while Indonesian women had a higher prevalence than South Korean women (39.9% vs. 31.2%). In terms of MetS components, Indonesians exhibited a lower prevalence of hypertriglyceridemia but higher rates of elevated blood pressure compared to South Koreans. Age stratification revealed higher MetS prevalence in young adult Indonesian men and women compared to their South Korean counterparts. This trend reversed in middle-aged men, and older adult women in both countries had similar MetS prevalences.

Conclusion: The overall prevalence of MetS in Indonesia was comparable to South Korea. However, gender and age stratifications showed differences, highlighting the need for country-specific interventions to reduce the burden of MetS and related cardiometabolic diseases.

3. Epidemiology of Obesity and Metabolic Syndrome

Metabolic-predicted Obesity Phenotypes and Risk of Colorectal Cancer in Malaysia: Decoding the Obesity Paradox

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Background: In Malaysia, the 'obesity paradox' reveals a higher proportion of obese individuals not developing metabolic dysfunctions, highlighting a research gap in understanding the link between obesity and colorectal cancer (CRC) risk. The diverse obesity-related metabolites contribute to a complex metabolic landscape, potentially influencing CRC risk. This multicentric retrospective matched case-control study explores the association between the metabolic-predicted obesity phenotypes (MetSOBs) and CRC risk in selected hospitals.

Methods: A total of 140 histologically confirmed CRC cases and 280 matched cancer-free controls were recruited from five public hospitals in Malaysia. They were categorized into MetSOBs phenotypes according to the metabolic syndrome (MetS) criteria as defined by the International Diabetes Federation and BMI ($\geq$ 25 kg/m2): metabolically healthy normal weight (MHNW), metabolically unhealthy normal weight (MUNW), metabolically healthy overweight/obese (MHO) and metabolically unhealthy overweight/obese (MUO). Cox regression was employed to determine the association between MetSOBs and the risk of CRC.

Results: MetS was significantly more prevalent among cases compared to controls (57.1% vs. 39.3%; χ2=12.01. p = 0.001). The prevalence of overweight was 27.9%, while obesity was 11.4% among the CRC cases. MUNW and MUO subjects were more prevalent among those aged <60 years old, females, Malays, and those with higher monthly income. With metabolic dysfunction defined as $\geq$3 MetS criteria, CRC cases had significantly higher proportions of MUNW (28.6% vs. 15.7%) and MUO (28.6% vs. 23.6%) phenotypes than cancer-free controls (χ2 = 14.16, p = 0.003). MUNW subjects had a 2.8-times higher odds of CRC risk (AOR = 2.27, 95% CI = 1.56, 4.93) while MUO subjects had 79% increased odds of CRC risk, compared to MHNW subjects (AOR = 1.79, 95% CI = 1.04, 3.08).

Conclusion: This pioneering research established MetSOBs phenotypes as a valuable tool for predicting CRC in the Malaysian population for personalized risk assessments and innovative preventive interventions.

3. Epidemiology of Obesity and Metabolic Syndrome

Predicting Metabolic Syndrome in Obese Adults: Integrating Gut Microbiome Diversity and Dietary Patterns with Machine Learning

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Background: The gut microbiome is key to metabolic processes and metabolic syndrome (MetS), especially in obese individuals. Diet impacts gut microbiota, but the combined effect of microbiome profiles and dietary patterns on predicting MetS is unclear. This study uses machine learning to investigate how gut microbiome diversity and diet predict MetS onset in obese adults, guiding personalized nutrition strategies.

Methods: We conducted a retrospective cohort analysis using data from the American Gut Project and UK Biobank, involving 10,000 obese adults aged 35-60. Participants provided stool samples for 16S rRNA sequencing to profile gut microbiota and completed food frequency questionnaires (FFQs) for dietary intake. Gut microbiome data were analyzed to determine microbial diversity and key taxa. Dietary data were categorized into macronutrients, micronutrients, and specific patterns (Mediterranean, Western). We employed a multi-layer ensemble model combining Convolutional Neural Networks (CNNs) for microbiome data and Gradient Boosting Machines (GBMs) for dietary data. The model was optimized using a genetic algorithm and validated through 10-fold cross-validation.

Results: The ensemble model achieved an accuracy of 94.1% (95% CI: 92.9% - 95.3%) and an AUC-ROC of 0.97 (95% CI: 0.96 - 0.98). Sensitivity and specificity were 90.5% (95% CI: 88.4% - 92.6%) and 92.8% (95% CI: 91.0% - 94.6%), respectively. Key predictive features included the relative abundance of Bacteroidetes, Firmicutes, and a high intake of dietary fiber. Participants adhering to a Mediterranean diet had a 2.5-fold reduced risk of developing MetS (HR: 0.40, 95% CI: 0.32 - 0.50). High Bacteroidetes levels combined with high-fiber intake were associated with the lowest MetS risk (HR: 0.22, 95% CI: 0.18 - 0.27).

Conclusion: Integrating gut microbiome and diet data with machine learning accurately predicts MetS. The diet-microbiota interaction is key to metabolic health and suggests personalized dietary strategies to reduce MetS risk. Future research will validate these results and develop targeted dietary interventions.

PE 03-05 3. Epidemiology of Obesity and Metabolic Syndrome

No association of rs121907892 with hyperuricemia and other metabolic parameters in Thai population

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Background: Hyperuricemia is defined as an elevated serum uric acid level. Nowadays, the disease burden of hyperuricemia is increasing worldwide. Among other countries, Thai people suffer from gout attack, significantly increased risk in those who have hyperuricemia, which is the most common risk factor for developing gout. A higher serum uric acid (UA) is associated with metabolic syndrome. Studies have shown that the genetic variation of Solute Carrier family 22 member 12 (SLC22A12) can also result in hyperuricemia, which is expressed at the apical side of the renal proximal tubule. The single nucleotide polymorphisms (SNP) at the loci stated above can lead to UA underexcretion. This study aimed to study the association between the rs121907892 variant and hyperuricemia.

Methods: In a cross-sectional study involving subjects from Nakornnayok, Thailand, 597 blood samples were collected from healthy people with age range of 20-60 years old. The SNP variant of rs121907892 was analyzed by using TaqMan SNP Genotyping Assays by StepOnePlus® Real-Time PCR Systems (Applied Biosystems, USA).

Results: The prevalence of hyperuricemia in this study was 24.79%, which was more common in females than in males, with the prevalence of male and female was 43.2% and 56.8%. The prevalence of metabolic syndrome was 12.40%, and also the prevalence of metabolic syndrome with hyperuricemia was 4.19%. The 597 participants were interpreted as GG genotype of rs121907892. The AA and AG genotypes were not found in this population. This result has shown that rs121907892 was consensually not associated with hyperuricemia and other metabolic parameters.

Conclusion: These results indicated that the variation of rs121907892 was not found. There is only GG genotype, known as wildtype, in this study.

PE 03-06 3. Epidemiology of Obesity and Metabolic Syndrome

Trends in prevalence of obesity and related cardio-metabolic and renal complications in Korea: a nationwide study 2007-2022

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Background: As obesity has increased, the burden of obesity related comorbidities accelerates. However, the prevalence and current status of obesity and its related comorbidities in Korean has not been evaluated.

Methods: Data from the 2007–2022 Korean National Health and Nutrition Examination Surveys database were analyzed (n=93,761). The prevalence of hypertension, diabetes, dyslipidemia, steatotic liver disease (SLD), cardiovascular diseases (CVD), chronic kidney disease (CKD) and cancer according to obesity and central obesity was investigated. The prevalence of obesity and its related comorbidities were also analyzed according to age groups and sexes.

Results: Prevalence of individuals with obesity has steady increased from 31.5% in 2007-2009 to 37.4% in 2020-2022. Among individuals with obesity, the prevalence of hypertension, diabetes, dyslipidemia, CKD and SLD also has increased. These increases were found across the age groups and both sexes. Among individuals with obesity, the proportions of metabolic dysfunction associated steatotic liver disease (MASLD) and MASLD with increased alcohol intake were increased. The increase in CKD prevalence was prominent in young (19-39 years) and middle age groups (40-59 years). The prevalence of CVD and cancer in population with obesity has increased, whereas the prevalence of CVD and cancer in old age group (≥ 60 years) has been plateau. When analyzing according to central obesity, similar results were observed.

Conclusion: With the increase in obesity, the prevalence of obesity related comorbidities in the Korean population has been rising. Young and middle aged population with obesity are vulnerable to obesity related comorbidities.

Association between obesity and the triglyceride glucose index as insulin resistance marker

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Background: The triglyceride glucose (TyG) index is an inexpensive clinical surrogate marker for insulin resistance. However, the relationship between TyG index and various body composition maker for obesity remains unclear. We evaluated the relationship between TyG index and various body composition maker for obesity using a large- scale population dataset from the Korea National Health and Nutrition Examination Survey (KNHANES) between 2008 and 2010.

Methods: We performed a cross-sectional study that included 19947 participants aged ≥ 19 years using the KNHANES. We divided the participants into TyG index quartiles. We evaluated the risk for highest quartiles of TyG index in the obesity defined by various body composition makers. The TyG index was calculated as ln [triglyceride (mg/dL) × fasting plasma glucose (mg/dL)/2]. Dual-energy X-ray absorptiometry was used to measure the body composition.

Results: Obesity by body mass index was associated with 2.987 time (95% CI: 2.794-3.193) higher risk for higher TyG index. Obesity by Waist circumference was associated with 3.170 time (95% CI: 2.959-3.396) higher risk for higher TyG index. Obesity by fat% was associated with 2.075 time (95% CI: 1.942-2.217) higher risk for higher TyG index. Among the subject with Obesity by BMI, WC (area under curve; AUC=0.610) was more associated with higher TyG index comparing fat% (AUC=0.418). Obesity. Subjects with obesity by both BMI and WC was 3.874 time (95%CI: 3.586-4.185) higher risk for higher TyG index comparing with subjects without obesity. Subjects with obesity by BMI or WC not both was 2.597 time (95%CI: 2.378-2.836) higher risk for higher TyG index comparing with subjects without obesity.

Conclusion: Higher TyG index was associated obesity by BMI, WC, and fat%. However, comparing BMI and WC, fat% was relatively lower associated with higher TyG index.

Linking Food Habits, Obesity and Smocking With Colorectal Cancer: Genetic And Epigenetic Insights

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Background: The prevalence of obesity and colorectal cancer (CRC) has increasing marginally in recent decades. The role of environment and life style is seen even in families inheriting muted high penetrance genes. Some of the environmental factors, non-vegetarian diet including red meat intake, smoking and drinking habit may be the high risk factor of colorectal cancer in India. The mutation in PTEN gene have been identified with high frequency in many sporadic malignant tumours. Involvement of PTEN promoter methylation has been reported in various cancer types but no such study has been made to evaluate the role of the PTEN tumour suppressor gene in colorectal cancer in Indian population.

Methods: A total of 223 tumour specimens diagnosed with CRC and their matched control tissue along with their clinical parameters were collected from the patients admitted to G.B. Pant Hospital, New Delhi. The clinicopathological parameters were determined by pathologist of the hospital. All cases were followed-up by their case documents. The $\chi 2$-test was used to analyze the association of PTEN hyper methylation with clinico-pathologic characteristics in colorectal carcinoma patients. $P<0.05$ was considered statistically significant.

Results: Out of total 223 cases studied, 114 (51%) of the CRC specimens have shown PTEN hypermethylation, 57% are smoker and interestingly 89% are obese among the all 223 patients studded so far. Further, hypermethylation was more common in late stage tumors (III & IV) than in early stage tumors (I & II) (39% versus 63%) (P=0.0003). Interestingly, out of total 114 methylation positive cases, 81(71%) are smoker and all are obese. All the poorly differentiated patients have both smoking and non-vegetarian habits.

Conclusion: There is strong evidence from our study is that the consumption of moderate amount of non-vegetarian diet and smoking can promote colorectal cancer. On that basis we were also able to provide evidence for an association of PTEN promoter hypermethylation with colorectal cancer and metastases. Our data suggest that obesity is regarded as one of the key environmental risk factors for the pathogenesis of CRC. Avoiding of having excess non-vegetarian diet and smoking can act as a primary prevention for CRC in both men and women. However, further studies are warranted to elucidate the role of obesity in colorectal carcinogenesis.

3. Epidemiology of Obesity and Metabolic Syndrome

EFFECT OF YOGA INTERVENTIONS ON SARCOPENIA – A REVIEW

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Background: Decline in skeletal muscle mass, also known as sarcopenia is more prevalent among older women as compared to older men. It is a component of fragility syndrome which indicates a significant health issue related to the progressive decline of muscle tissue quality and strength.

Methods: A systematic, thorough search using different databases like Cochrane Systematic Reviews, Google Scholar and PubMed was done for relevant literature on the topic.

Results: 15 studies met inclusion criteria with a total sample of 2069. The review revealed significant effects (5% level of significance) favouring the yoga group for the various physical function outcomes compared with active controls. Six studies measured gait speed, showing significant effectiveness (p<0.05). Ten studies measured balance, showing significant effect, three studies measured physical function, handgrip strength and quality of life showing significant effect on sarcopenia compared to baseline (p<0.05).

Conclusion: Significant effects favouring yoga were found for balance, flexibility, strength, depression, perceived physical health and functional performance. Thus, it can be suggested that yoga has beneficial effects which can be used an alternative method, which is easy to perform, safe to adopt as well as plays an integral part in one's daily life in alleviating diseases and promoting health with no side effects.

 Keywords : sarcopenia, yoga, gait speed, muscle strength, balance, flexibility

3. Epidemiology of Obesity and Metabolic Syndrome

Prevalence of Metabolic Syndrome among Rural Adult Population in Mansa District of Punjab, India

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Background: Metabolic syndrome (MetS) is a major health concern, particularly in populations undergoing socio-economic and lifestyle transitions. The main objective was to determine the prevalence of metabolic syndrome among rural population of Punjab adults.

Methods: The present study attempts to understand the prevalence of MetS. The present study involved the screening of 2328 participants between the age range of 30-75 years of either sex. Thus 1835 participants finally included in the study; those who did not give blood sample, were excluded from the study. The detailed socio-demographic, anthropometric and physiological data were collected using standard tools and protocols. Blood sample were used to estimate the lipid profile and glucose level using an Automated Biochemical Analyzer (Erba). The statistical analysis was done using SPSS-27 and MS Excel.

Results: The overall prevalence of MetS was found to be 36.8% (38.6% in males and 35.4% in females) by ATP-III criteria. MetS was found to be higher in the age group between 50-59 years (25.8%) followed by 60-69 years (25.6%), 40-49 years (22.1%), 30-39 years (16.7%) and 70+ years (9.8%) respectively.

Conclusion: The present study highlights the increasing prevalence of MetS among the rural population of north India, especially among age group 50-59 and 60-69 years. Thus, early detection and improved treatment provision are urgently required in addition to lifestyle modification and physical exercise to combat the increasing prevalence of MetS and reduce the burden of cardiovascular diseases.

Table: Age-wise and sex-wise distribution of MetS among study population

Variables	MetSN (%)	χ2, p-value
Sex		
Male	309 (38.6)	1.96, 0.161
Female	366 (35.4)	
Age Groups		
30-39 Years	113 (16.7)	28.96, <0.001*
40-49 Years	149 (22.1)	
50-59 Years	174 (25.8)	
60-69 Years	173 (25.6)	
70+ Years	66 (9.8)	
Total = 675 (36.8)		

PE 03-11   3. Epidemiology of Obesity and Metabolic Syndrome

Triglyceride Glucose Index Trajectory Is Related To Overall And Cardiovascular Mortality: A Competing Risk Analysis

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Background: The link between changes in insulin resistance and the risk of overall and cardiovascular disease (CVD) mortality remains unclear. This study aimed to examine the association between triglyceride-glucose (TyG) index trajectories and the risk of overall and CVD-specific mortality using data from the Korea National Health Insurance Service-National Sample Cohort.

Methods: Data from 233,546 adults aged ≥19 years were analyzed. During the median 4-year exposure period (2009–2014), participants were classified into increasing, stable, or decreasing TyG index trajectory groups. During the median 8.13-year event accrual period (2015–2021), information on specific causes and dates of mortality was collected. Cox proportional hazard regression analysis was used to estimate the risk of overall mortality, and competing risk analysis was performed for CVD death, considering non-CVD death as competing risks.

Results: There were 7918 mortality events (651 CVD deaths and 7267 non-CVD deaths) were captured. Compared with the stable group, the fully-adjusted hazard ratios (95% confidence intervals) in the increasing group were 1.09 (1.03–1.15) for overall mortality and 1.23 (1.01–1.50) for CVD mortality. The significant relationship for overall mortality persisted in subgroups aged <50 years, men, and those with obesity, hypertension, and diabetes. For CVD mortality, it was significant in subgroups aged 50–69 years, those with obesity, and diabetes.

Conclusion: An increasing trend in TyG index was independently associated with overall and CVD mortality. Serial monitoring of the TyG index and prioritizing strategies to reduce insulin resistance should be considered to lower mortality risk.

PE 03-12   3. Epidemiology of Obesity and Metabolic Syndrome

Age and Gender-Specific Body Composition assessed by Bioelectrical Impedance Analysis: 2022 Korea National Health and Nutrition Examination Survey

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Background: In 2021, the prevalence of overweight and obesity among OECD countries was 57.8%, highlighting obesity as a major global health concern. The Body Mass Index does not account for the distribution of adipose tissue. Consequently, there is increasing advocacy for defining obesity from a more comprehensive perspective that includes additional medical and functional factors. This study aims to present the distribution of body composition indices by gender and age among the Korean population.

Methods: The Korea National Health and Nutrition Examination Survey data was extracted using two-stage stratified cluster sampling, a complex sampling design method that accounts for factors such as stratification, clustering, and weighting. This study used data from the 9th KNHANES, conducted in 2022. Participants underwent a body composition assessment by Bioelectrical Impedance Analysis using the InBody 970 (Biospace, Korea), measuring lean body mass, muscle mass, and body water. Subjects were categorized by gender and age. Weighted means and standard errors were computed while accounting for the complex survey design.

Results: We analyzed a total of 4,425 participants aged 20 years or older who participated in body composition testing. Among men, the highest body fat mass was 20.1 kg, observed in those in their 30s. For women, the highest body fat mass was 20.4 kg, observed in those in their 60s. The average ratio of body fat mass to lean body mass was 0.3 for men and 0.5 for women, indicating a significant gender difference. Both men and women showed an increase in the body fat mass to lean body mass ratio as age advanced.

Conclusion: This study aims to redefine obesity by incorporating body composition indices, considering variations by gender and age, and emphasizes the need for more precise body composition analysis. These findings contribute to the development of enhanced health promotion strategies and personalized obesity treatment approaches.

PE 03-13 3. Epidemiology of Obesity and Metabolic Syndrome

Association of different obesity Phenotype, liver steatosis and fibrosis, wellbeing and muscle strength in Indian Adults with Non-Alcoholic Fatty Liver Disease

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Background: NAFLD represents a significant health concern globally, particularly among Indian adults, where prevalence rates are on the rise.

Methods: This Cross-sectional study included 200 patients (n=50 each group) aged ≥ years diagnosed for fatty liver by transient elastography. BMI (WHO criteria) and metabolic syndrome (ATP-III classification) was used to define obesity phenotypes as MHNO, MUNO, MHO and MUO. Fibrosis, sleep quality and QoL were assessed using FIB-4, PSQI and SF-36 questionnaire respectively. Hydraulic handgrip dynamometer was used to measure muscle strength.

Results: The mean BMI in MHO and MUO group was 32 ± 2.1 kg/m2 and 30.7 ± 3.6 kg/m2 respectively whereas it was 23 ± 1.2 and 24.4 ± 1.8 among MHNO and MUNO group. The mean age of patients among MUO group is the highest (43 ± 4.3) years followed by MHO (39 ± 9.6), MUNO (34 ± 5.4) and MHNO (33 ± 15.2). Cap scores were highest in MHO group (325 ± 36) as compared to the other three groups (MUO:MUNO:MHNO 330 ± 28: 319 ± 9.1: 317 ± 21). Liver fibrosis demonstrated a progressive increase across phenotypes, with mean scores of 0.82 ± 0.3 (MHNO), 0.94 ± 0.5 (MUNO), 1.41 ± 0.2 (MHO), and 1.5 ± 0.6 (MUO) ($p<0.001$). Sleep Quality scores were significantly higher in MUO (MS:9) and MHO (MS:6) compared to MUNO (MS:3) and MHNO (MS:2) groups ($p<0.01$). Among QoL scores MUO (43 ± 11.6) and MUNO (43 ± 14.2) participants reports lower scores compared to MHO (55 ± 23.4) and MHNO (62.5 ± 19.4) individuals ($p<0.001$). Muscle strength was significantly diminished in MUO (Male:31.4 kg and Female 22.4 kg in dominant hand) and MUNO (Male: 30.7 kg and Female 20.1 kg) groups compared to MHO (Male: 37.6 kg and Female: 28.6 kg) and MHNO (Male: 36.7 kg and female 26.9 kg) counterparts ($p<0.01$).

Conclusion: CAP scores demonstrate a graded escalation from MHNO to MUO signifying a robust association between obesity phenotypes and liver fibrosis severity. Sleep quality was poor in MUO and MHO and there is diminished QoL among MUNO and MHNO groups indicating a substantial influence of metabolic health on sleep and overall, wellbeing. A decrement in muscle strength is observed in MUO and MUNO in comparison to MHO and MHNO, accentuating the adverse impact of metabolic dysfunction on muscular performance.