论著·循证医学

脂质蓄积指数与中国成年人高血压关系的meta分析

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［摘要］**目的·**探讨脂质蓄积指数（lipid accumulation product，LAP）与中国成年人高血压的关系。**方法·**通过检索英文数据库PubMed、Web of Science，中文数据库中国知网、万方数据知识服务平台，搜集从建库到2022年8月中国成年人LAP与高血压相关研究。由2位研究人员根据纳入和排除标准分别独立地对所有检索到的文献进行筛选，并使用JBI（Joanna Briggs Institute）诊断性研究量表对研究人群选择、可比性、暴露评价和结果等方面进行文献质量评估。对纳入的文献提取样本量、性别、灵敏度、特异度等信息，并使用Stata 16.0软件进行meta分析。**结果·**共纳入6篇文献，其中英文文献5篇，中文文献1篇。纳入文献的JBI偏倚评分为14~17分，均大于总分的70%，认为偏倚较小。纳入样本总数48 329例，其中高血压患者15 746例。Meta分析结果显示，在总人群中，LAP预测高血压的灵敏度为0.50（95%*CI* 0.35~0.64），特异度为0.78（95%*CI* 0.66~0.86）；在女性中灵敏度为0.48（95%*CI* 0.32~0.64），特异度为0.77（95%*CI* 0.64~0.86）；在男性中灵敏度为0.56（95%*CI* 0.39~0.72），特异度为0.64（95%*CI* 0.49~0.77）。纳入的总体人群综合受试者操作特征曲线（summary receiver operator characteristic curve，SROC曲线）下面积为0.70（95%*CI* 0.66~0.74），表明LAP和高血压存在一定的相关性。**结论·**在中国成年人群中，LAP与高血压有一定关联性。

［关键词］脂质蓄积指数；高血压；成年人；中国人；meta分析

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Meta analysis of correlation between lipid accumulation product and hypertension in Chinese adults

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[Abstract] Objective·To explore the correlation between lipid accumulation product (LAP) and hypertension in Chinese adults. **Methods·**By searching the English literature databases including PubMed and Web of Science, and the Chinese literature databases including CNKI and WanFang Data Knowledge Service Platform database, the earliest literature related to LAP and hypertension in Chinese adults that could be retrieved from databases establishment to August 2022. Two researchers independently screened all the retrieved literature according to the inclusion and exclusion criteria, and used the diagnostic research scale developed by Joanna Briggs Institute (JBI) to evaluate the literature quality of the selection, comparability, exposure evaluation and results of the study population. The sample size, gender, sensitivity, specificity and other information were extracted from the included literature. Stata 16.0 software was used for meta-analysis. **Results·**A total of 6 articles were included, including five in English and one in Chinese. The JBI bias scores of the included articles ranged from 14 to 17 points, all of which were greater than 70% of the total score, so the biases could be considered small. The total number of samples included was 48 329, including 15 746 patients with hypertension. The results of meta-analysis showed that in the total population, the sensitivity of LAP in predicting hypertension was 0.50 (95%*CI* 0.35－0.64), and the specificity was 0.78 (95%*CI* 0.66－0.86); In women, the sensitivity was 0.48 (95%*CI* 0.32－0.64), and the

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specificity was 0.77 (95%*CI* 0.64–0.86); In males, the sensitivity was 0.56 (95%*CI* 0.39–0.72), and the specificity was 0.64 (95%*CI* 0.49–0.77). The area under the summary receiver operator characteristic curve (SROC curve) of the total population included was 0.70 (95%*CI* 0.66–0.74), indicating that there was a certain correlation between LAP and hypertension. **Conclusion**·In Chinese adult population, LAP is associated with hypertension to a certain extent.

[Key words] lipid accumulation product (LAP); hypertension; adult; Chinese; meta-analysis

高血压病程长、成因复杂、并发症严重，是危害居民身体健康和造成社会经济负担的重要因素[1]。我国居民死亡归因于高血压的人数从1990年的122.22万例增加至2019年的259.99万例，近30年增幅为112.72%[2]，因此识别早期高血压的危险因素有着重要意义。肥胖作为高血压危险因素之一，通过刺激肾素-血管紧张素系统、降低瘦素活性和促进血管重塑的促炎过程等机制显著增加高血压发生的风险[3]。肥胖被认为是脂肪的过度累积。随着对脂肪组织认识的深入，研究人员[4]发现脂肪组织根据分布部位的不同通常有着不同的功能。内脏脂肪组织在心血管疾病的发生发展中起到重要作用[5]，而皮下脂肪则更多起到保护性作用。不能单纯认为较高的体质量或整体肥胖总是有害的[6-8]，因此需要一种简单有效反映内脏脂肪的指标。

KAHN等[9]提出的脂质蓄积指数（lipid accumulation product，LAP）是结合腰围与三酰甘油（triacylglycerol，TAG）的结果，能够较为准确地反映内脏脂肪和中心性肥胖的情况，计算公式分别为男性LAP=［腰围（cm）−65］×TAG（mmol/L），女性LAP=［腰围（cm）−58］×TAG（mmol/L）。国内外研究[10-12]均发现LAP与心脑血管疾病有密切联系。对伊朗、美国、荷兰和德国的研究进行汇总分析后发现，LAP不但可以作为高血压的预测因子，还可以作为糖尿病和全因死亡率的预测因子[13]。美国第三次全国健康和营养调查（the Third National Health and Nutrition Examination Survey，NHANES Ⅲ）显示，LAP在识别成年人总胆固醇（total cholesterol）、高密度脂蛋白胆固醇（high-density lipoprotein cholesterol，HDL-C）、低密度脂蛋白胆固醇（low-density lipoprotein cholesterol，LDL-C）等11个评估心血管风险因素方面的表现优于体质量指数（body mass index，BMI）[14]。日本中年男性LAP（*OR*=43.65，95%*CI* 4.33~4.09）相比于LDL-C/HDL-C（*OR*=1.88，95%*CI* 1.69~2.10）、TAGs/HDL-C（*OR*=2.65，95%*CI* 2.46~2.86），对高血压的识别能力更优（*P*<0.001）[15]。在我国内蒙古的男性中，与BMI（*OR*=2.80，95%*CI* 1.86~4.21）相比，LAP（*OR*=4.21，95%*CI* 2.78~6.38）与高血压风险之间的相关性更强（*P*<0.001）[16]。2017—2018年南京市5个区共纳入59 251人的慢性病防控社会因素调查研究[17]发现，随着LAP水平的升高，高血压的患病风险随之升高。

我国地域辽阔，不同地区、不同民族生活习惯有较大差异。与南方人相比，我国北方人有更高的体质量和TAG水平[18-19]。与欧洲人相比，中国人的内脏脂肪组织在既定BMI或腰围的情况下更多[20]。由于LAP是结合腰围与TAG的结果，不仅反映身体的代谢情况，也能间接反映心脏代谢。如果研究确认LAP与高血压存在关联，那么在大规模人群调查和高血压高危人群日常监测中，LAP作为一种简便、低成本的方法可以发挥重要作用。因此本研究对中国成年人LAP和高血压关系的研究进行文献检索，并选取研究结果中包含灵敏度和特异度数据的文章进行meta分析，旨在明确LAP与中国人群高血压的关联及可能的预警作用，为LAP在大规模流行病学调查和高血压危险因素监测的推广和应用提供循证依据。

1　资料与方法

1.1　文献检索

英文文献采用PubMed、Web of Science数据库进行检索，中文文献采用中国知网、万方数据知识服务平台数据库进行检索。检索时间从数据库建库到2022年8月。检索词设定为“高血压”“脂质蓄积指数”“hypertension”“LAP”“lipid accumulation product”。选定范围的文章的参考文献也被纳入补充范围。

1.2　文献纳入与排除标准

文献纳入标准：①研究对象为成年人（≥18岁）。②研究地域为中国。③文献中样本信息明确，包含灵敏度、特异度结果。排除标准：①同样的数据重复发

表。②无法提取或计算所需数据。③未公开发表的文献。

1.3 质量评价

文献质量采用JBI（Joanna Briggs Institute）诊断性研究量表对研究人群选择、可比性、暴露评价和结果等方面进行评估，共计10个条目，采用“是”“否”“不适用”作答。若得分大于总分的70%，则认为偏倚风险较低[21]。由2位研究人员分别独立进行文献的筛选和评分，交叉核对，出现分歧时与第3位研究人员进行协商。

1.4 统计学分析

使用Stata 16.0软件进行数据分析和绘图，各效应量均采用其95%*CI*。总体人群综合受试者操作特征曲线（summary receiver operator characteristic curve，SROC曲线）用于评估LAP的预测能力[22]。异质性选用Cochran *Q*检验进行测定，当$P<0.10$且$I^2\geq50$时认为存在异质性并采用随机效应模型进行分析，并根据发表时间、地区进行亚组分析。发表偏倚采用漏斗图进行评估，敏感性分析采用逐一剔除法。$P<0.05$表示差异具有统计学意义。

2 结果

2.1 检索基本情况

共检索到中文文献319篇，英文文献225篇。剔除重复文献和与主题不符合的文献后剩余21篇，剔除不符合纳入标准的文献，最终纳入6篇文献进行分析。具体流程见图1。

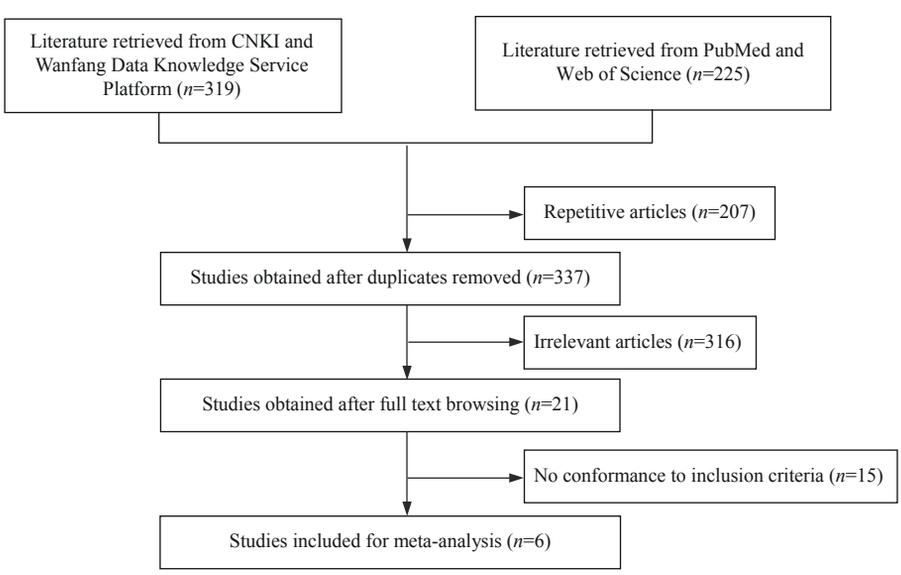


图1 文献检索流程图

Fig 1 Flowchart of the study screening

2.2 文献基本情况

共纳入文献6篇，其中中文文献1篇、英文文献5篇，研究时间跨度为2005—2017年。根据中国地理南北分界线和行政区[23]划分研究地区为东部地区1篇[24]、北部地区3篇[25-27]、南部地区2篇[28-29]。纳入的参与者共计48 329例，其中高血压患者15 746例，文献的JBI偏倚风险得分为14~17分，表明文献偏倚风险均较低，详细信息及具体得分参见表1。

2.3 发表偏倚

漏斗图显示研究大致均匀分布在两侧，表明存在发表性偏倚的可能性较小（图2）。

2.4 Meta分析结果

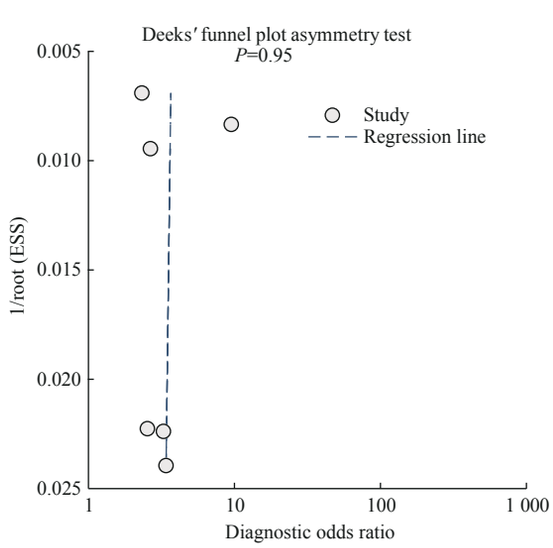
对纳入研究进行异质性检验，结果显示存在明显的异质性（$I^2=99.95\%$，$P<0.01$）。采用随机效应模型分析（图3A）显示，LAP预测高血压的灵敏

表 1　纳入文献基本情况及质量评分

Tab 1　Basic information and quality score of included literature

The first author	Research area	Study time	Hypertension definition	Research type	Total sample size	Number of patients with hypertension	Quality score/ point
YAN	Pudong New Area, Shanghai	January, 2012–March, 2013	Systolic blood pressure (SBP) ≥ 140 mmHg, diastolic blood pressure (DBP) ≥ 90 mmHg, or a history of oral antihypertensive medication	Cross-sectional study	2 092	1 066	15
SONG	Bengbu, Anhui Province	2018	SBP≥140 mmHg, DBP≥90 mmHg, or the subject reported with a medical history of antihypertensive medication	Cross-sectional study	1 777	433	14
WANG	Liaoning Province	2012	Blood pressure level of at least 140/90 mmHg, individuals who were on antihypertensive medications or a prior diagnosis of hypertension	Cross-sectional study	11 400	5 684	17
HUANG	Foshan, Fujian Province	2017	Prehypertension was defined as SBP 120–139 mmHg and/or DBP 80–89 mmHg, and hypertension was defined as SBP≥140 mmHg, DBP≥90 mmHg and/or a reported medical history of antihypertensive medication	Cross-sectional study	1 681	458	17
LEE	The Taiwan region	2022	Hypertension was defined as a self-reported history, SBP≥ 140 mmHg, or DBP≥90 mmHg during follow-up	Cohort study	21 466	3 157	16
LUO	Dalian, Liaoning Province	2011	Blood pressure≥140/90 mmHg and/or persons with confirmed hypertension and receiving treatment	Cross-sectional study	9 913	4 948	14

Note: 1 mmHg=0.133 kPa.

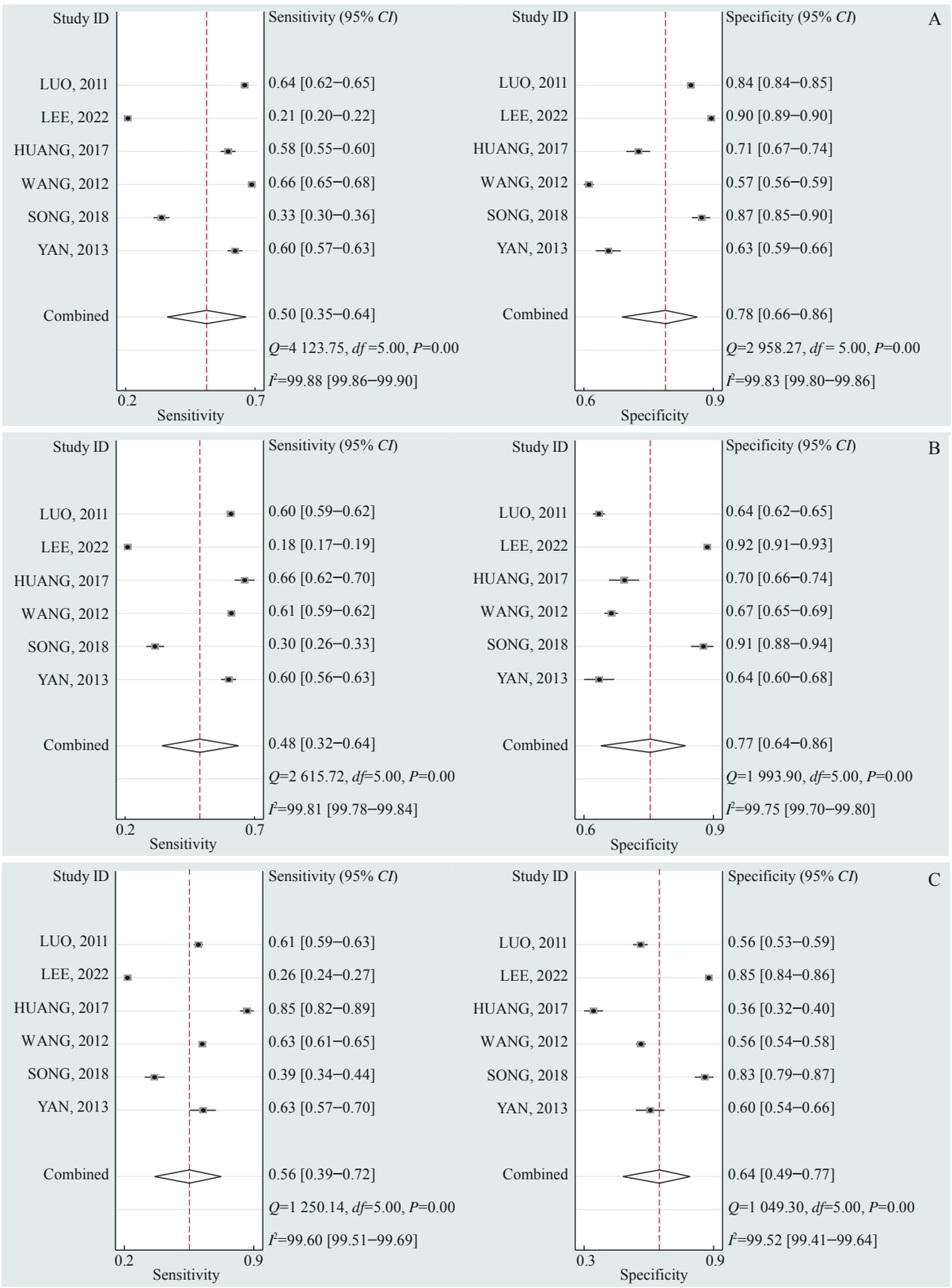


Note: ESS—explained sum of squares.

图 2　漏斗图

Fig 2　Funnel plot

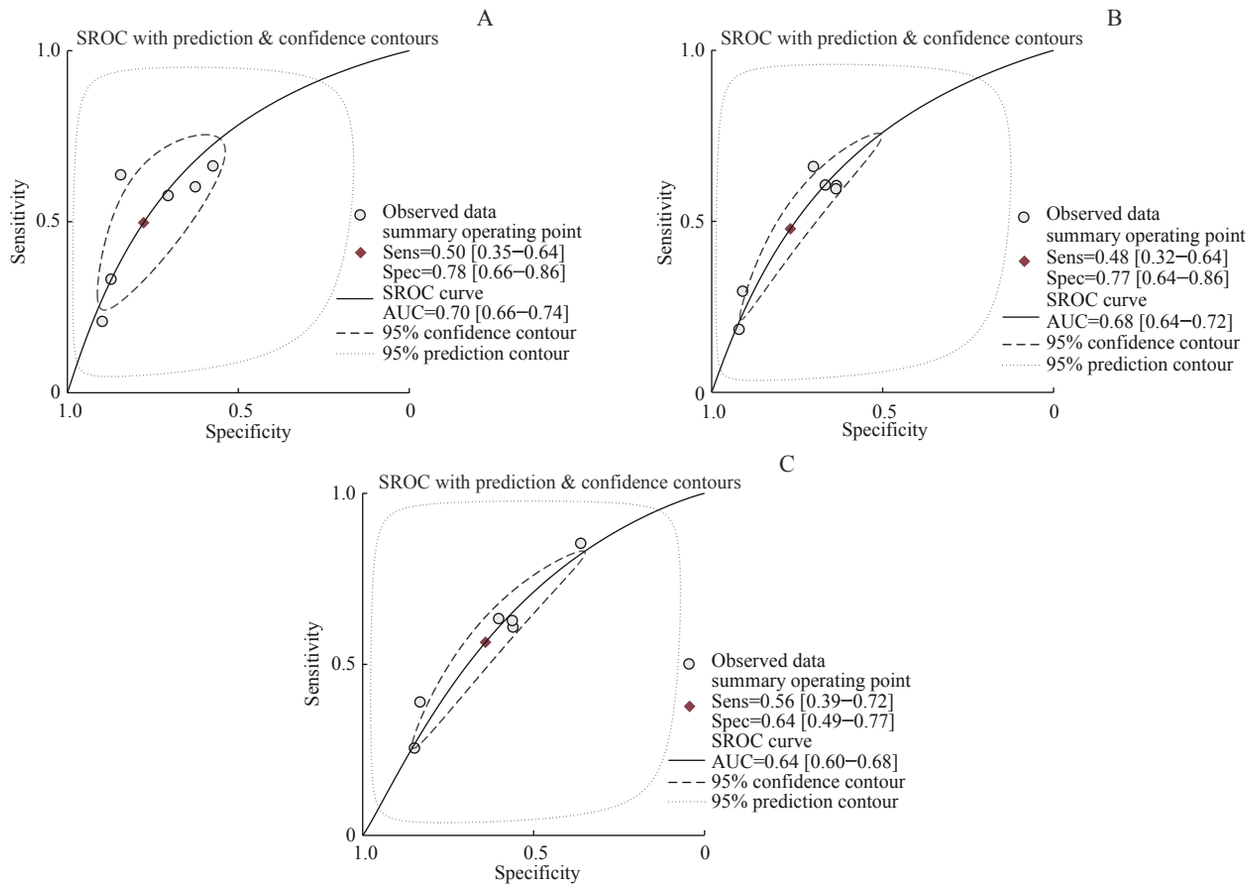
度为 0.50（95%*CI* 0.35~0.64），特异度为 0.78（95%*CI* 0.66~0.86）。按性别进行亚组分析，异质性检验显示男性和女性均存在明显异质性（I^2=99.60%，*P*<0.01；I^2=99.78%，*P*<0.01）。采用随机效应模型分析，结果（图 3B、C）显示女性 LAP 预测高血压的灵敏度和特异度分别为 0.48（95%*CI* 0.32~0.64）和 0.77（95%*CI* 0.64~0.86）；男性 LAP 预测高血压的灵敏度和特异度分别为 0.56（95%*CI* 0.39~0.72）和 0.64（95%*CI* 0.49~0.77）。如图 4 所示，纳入人群的 SROC 曲线表明 LAP 和高血压存在一定的相关性，曲线下面积（area under the curve，AUC）为 0.70（95%*CI* 0.66~0.74）；男性群体 AUC 为 0.64（95%*CI* 0.60~0.68），女性群体 AUC 为 0.68（95%*CI* 0.64~0.72）。敏感性分析结果显示，在剔除任何 1 篇文献后，合并的敏感度、特异度无明显改变。



Note：A. Total population included. B. Females included. C. Males included.

图3 LAP预测中国成年人高血压能力的meta分析森林图

Fig 3 Meta-analysis forest chart of the ability of LAP to predict hypertension in Chinese adults



Note：A. Total population included. B. Females included. C. Males included.

图4　LAP预测中国成年人高血压能力的SROC曲线

Fig 4　SROC curves of LAP predicting hypertension ability in Chinese adults

3　讨论

本研究对中国成年人LAP和高血压关系的研究进行检索，并选取研究结果中包含灵敏度和特异度数据的文章进行meta分析。研究结果提示LAP与中国人群高血压存在一定的关联及可能的预警作用[AUC=0.70（95%*CI* 0.66~0.74），其中男性为0.64（95%*CI* 0.60~0.68），女性为0.68（95%*CI* 0.64~0.72）]，为LAP在大规模流行病学调查和高血压危险因素监测的推广和应用提供了循证依据。

与肥胖相关的高血压，其发生机制是复杂的，超重、肥胖人群可能通过改变瘦素、内皮素、白细胞介素-6（interleukin-6，IL-6）等细胞因子的分泌水平影响交感神经系统和内皮细胞功能，并导致炎症反应和产生胰岛素抵抗[30-31]。各种脂肪组织功能复杂且不同脂肪组织的功能不同，许多研究[32-33]发现肥胖的临床风险更多取决于肥胖的分布而不是肥胖的程度。内脏脂肪组织在心血管疾病的发生发展中起到重要作用，而皮下脂肪则更多起到保护性作用[5]。内脏脂肪不但是胰岛素抵抗、血脂异常和心血管疾病发生的主要原因[34]，同时可以通过释放血管紧张素原、血管紧张素转换酶和组织蛋白酶来激活肾素-血管紧张素系统[35]。传统描述肥胖相关心血管风险的指标如BMI，并不能完全反映脂肪的分布情况。腰围被证明与胰岛素抵抗和心血管疾病发生风险有关[36-38]，但无法准确区分内脏脂肪和皮下脂肪。TAG不仅与内脏脂肪相关，也与心血管疾病发生风险增加相关[39]。因此由腰围和TAG的乘积得到的LAP，被认为能够更好地预测高血压发生风险。多项研究[12,40-42]表明，LAP与包括高血压在内的多种慢性病的关联性大于BMI。

本研究存在一定的局限性。首先，纳入文献的异质性较强可能与研究对象入组时间跨度大、高血压的评定标准不同有关。中国东部和北部地区的研究开展时间较早（2011—2018年）[24-27]，南部地区开展较晚（2017—2022年）[28-29]。多数研究[24-28]属于横断面研

究，高血压人群的定义为现场测量收缩压（systolic pressure，SBP）≥140 mmHg或舒张压（diastolic pressure，DBP）≥90 mmHg和/或服用抗高血压药物史、自报既往诊断为高血压的个体，LEE等[29]的研究将随访期间出现高血压（SBP≥140 mmHg，DBP≥90 mmHg）的参与者亦定义为高血压个体。但HIGGINS[43]指出，数据正确且纳入标准合理的情况下，任何数量的异质性都是可以接受的。其次，高血压的发生与多种因素有关，且受降脂、降糖等多种药物的影响，此次纳入的6项研究未包括上述变量信息，在分析LAP与高血压关系时无法对上述因素进行调整。最后，本研究纳入的多为横断面研究，无法确定LAP与高血压的因果关系。

综上所述，将人体测量数据和脂质参数整合而形成的LAP，与中国成年人群高血压存在一定的关联性，且在男性和女性中均存在。由于LAP测定简便、成本低，因此作为一种肥胖监测指标，适宜在大规模人群调查和高血压高危人群日常监测使用。

利益冲突声明/Conflict of Interests

所有作者声明不存在利益冲突。

All authors disclose no relevant conflict of interests.

作者贡献/Authors′ Contributions

马卓然负责研究设计、初稿撰写、文献检索与数据分析；袁安彩和陈潇雨负责文献质量评价；蒋惠如负责文献检索；卜军、张薇负责稿件修改。所有作者均阅读并同意了最终稿件的提交。

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