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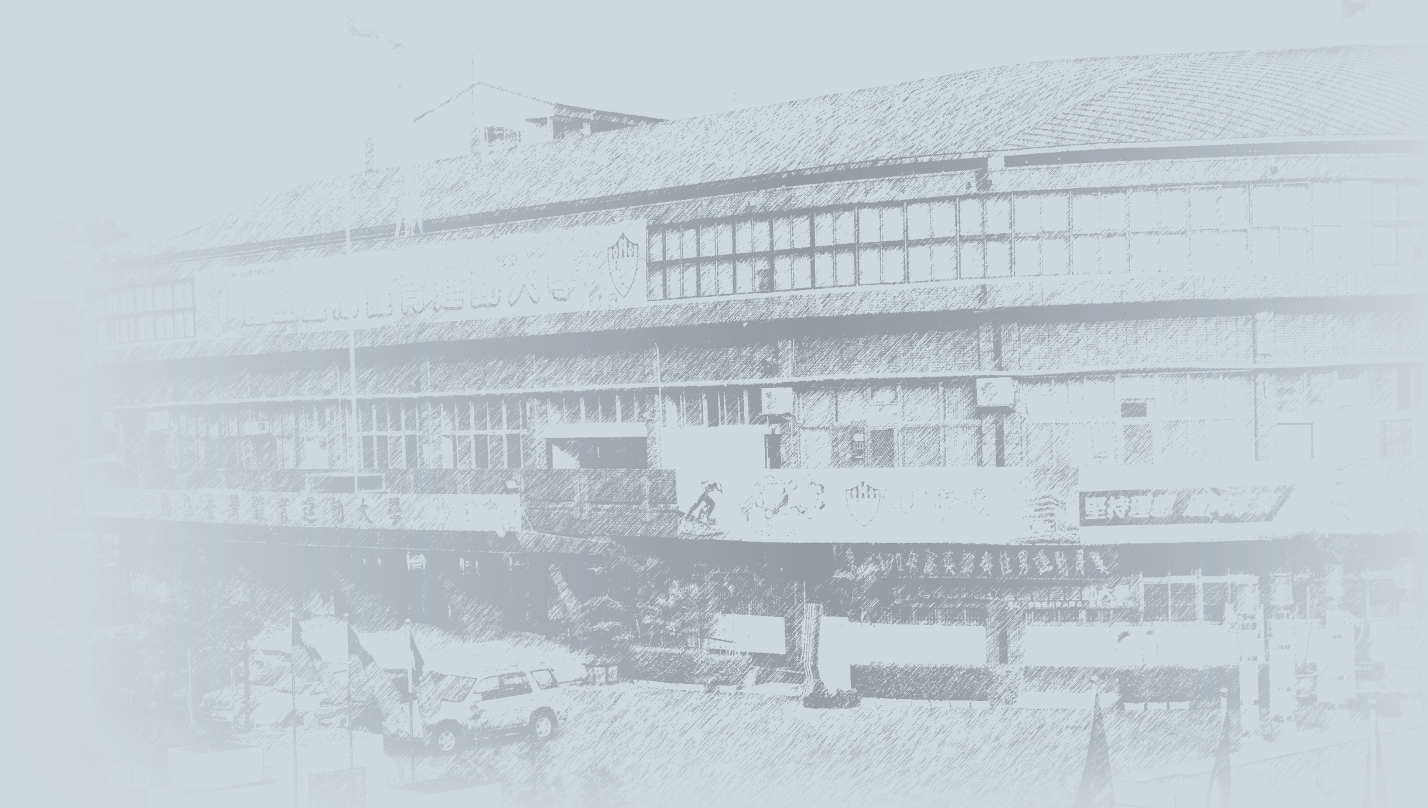

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目　錄

增強式訓練對籃球運動員衝刺及敏捷性影響之文獻回顧

陳紫苓、唐誌陽
國立臺灣體育運動大學運動健康科學學系

摘要

籃球是一項高強度的團隊運動，需要跳躍、衝刺和改變方向的能力，對技巧和戰術技能要求很高，對於籃球運動員而言，衝刺及敏捷性能力是重要的，一些過去研究中顯示增強式訓練可增加短期肌力，其訓練效果可提升衝刺速度，也可縮短肌肉反應時間，對敏捷性的提升也有幫助，但其訓練效果對於提升衝刺及敏捷性能力尚存許多爭議與限制，且各研究的訓練方式及內容也不一致。因此，本篇研究目的是以文獻回顧方式，針對過去籃球運動員進行增強式訓練的研究，了解對衝刺及敏捷性能力是否有正向影響，並且整理出訓練效益較大之訓練方式及內容。最後，經由研究結果得知，籃球運動員在進行增強式訓練時，可結合個別化的肌力訓練，且在沙地或柔軟地面進行漸進式增加強度且總跳躍次數至少 1140 下的訓練處方，方可有效提升衝刺及敏捷性能力。

關鍵字：籃球運動、增強式訓練、籃球運動表現

通訊作者：唐誌陽
E-mail：chihyang@ntus.edu.tw
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壹、前言

一、研究背景

籃球運動是一項高強度的團隊運動，需要跳躍、衝刺 (sprints) 和改變方向的能力 (change-of-direction; COD)，對技巧和戰術技能要求很高 (Stojanović et al., 2018; Taylor et al., 2017)。

衝刺能力是籃球運動表現與身體需求中的關鍵之一 (Petway et al., 2020; Scanlan et al., 2015; Stojanović et al., 2018)，包括運球、防守還原 (defensive recovery)、攻防轉換 (defensive transition)(Pinheiro Paes et al., 2022)；敏捷性 (agility)，也就是快速變向能力 (Bloomfield et al., 1994; Clarke, 1959; Mathews, 1973)，涉及全身，包含預先判斷及當下的加速或減速運動，常見在比賽中的運球後和上籃完成時 (Sheppard & Young, 2006)，而無論當下的目的是進攻還是防守，考慮到決定比賽勝負的時間很短，所以快速移動的能力是必須的 (Barrera-Domínguez et al., 2023)，且也有研究顯示，若要在籃球比賽中贏過對手的身材優勢，就必須提升快速變向能力 (Brini et al., 2020)。因此對於籃球運動員來說，衝刺及敏捷性能力的提升是相當重要，應為日常訓練計劃裡的一環。

籃球也是一項需要短期肌力的運動項目，而短期肌力在許多比賽情況下也很重要，隨著賽程的密集度和專項賽事增多，短期肌力訓練開始得到運動員及教練們的重視 (Cengizel et al., 2022)，有研究顯示增強式訓練可增加短期肌力，其訓練效果可提升衝刺速度，因此在技巧和戰術訓練中加入了短期增強式訓練，以提高運動員的表現 (Chelly et al., 2010)

增強式訓練是一項可以提升肌力表現的訓練 (Chu, 1983)。這種訓練方式是利用牽張縮短循環 (stretch-shortening cycle, SSC)，使肌肉進行離心牽張 (eccentric stretch) 後，立即向心收縮 (concentric contraction) (Rassier & Herzog, 2005)，可誘發肌肉的力量 - 速度關係 (Force-velocity Relationships)、肌肉羽狀角度 (muscle pennation angle) 和肌纖維類型轉變 (muscle fiber-type transition) 相關的生理適應能力 (Markovic & Mikulic, 2010)，可最大限度地提高肌肉肌腱複合體 (muscle tendon unit) 的力量來幫助縮短肌肉反應時間 (Rassier & Herzog, 2005)，

且此訓練方式可在多樣的環境中使用，經濟成本低也是一項優勢 (Oxfeldt et al., 2019)。

過去針對籃球運動員相關的增強式訓練，有些研究顯示此訓練對於衝刺能力是有正向影響的 (Hernández et al., 2018; Zribi et al., 2014)，也有些則無 (Brini et al., 2023; Munshi et al., 2022; Palma-Muñoz et al., 2021)，而敏捷性方面也是如此 (Brini et al., 2023; Cengizel et al., 2022; Gonzalo-Skok et al., 2019)，目前尚無研究針對增強式訓練的強度、內容進行統整。

二、研究目的

本研究的目的是想透過文獻回顧的方式，針對過去籃球運動員進行增強式訓練的研究，以了解對籃球運動員的衝刺能力及敏捷性是否有正向影響，並且藉由納入的研究裡統整出訓練效益較大的增強式訓練的方式及內容。

貳、研究方法

文獻搜尋的資料庫採用 PubMed 和 EBSCOhost，使用關鍵字「Basketball」、「plyometrics」、「sprint」、「agility」，並搜尋 2013 年到 2023 年 10 年間有關之文獻。

所有文章必須符合：籃球，增強式訓練介入並評估衝刺及敏捷性能力之改變。

排除標準包含：一、碩博士論文；二、非英文期刊論文；三、無全文；四、非 Clinical Trial (臨床試驗) 及 Randomized Controlled Trial (隨機對照試驗) 的期刊；五、非增強式訓練介入；六、期刊內容不符合搜尋的關鍵字；七、非籃球運動員；八、無評估衝刺及敏捷性能力。

隨後針對參與者資料（人數、性別）、實驗設計（分組、各組人數與年齡）、介入方式（增強式訓練介入時間與方法）與研究結果（評估方式、衝刺及敏捷性能力實驗介入結果）進行文獻資料統整及分類。

參、結果

一、文獻檢索結果

在 EBSCOhost 上搜尋了 11 篇文獻，PubMed 則為 9 篇文獻，刪除出非介於 2013~2023 之期刊以及非英文之期刊各一篇，刪除在 PubMed 裡沒有臨床實驗及隨機對照試驗的期刊 6 篇、在 EBSCOhost 裡非增強式訓練介入的 2 篇、在 EBSCOhost 裡非籃球運動員的 1 篇，並且刪除重複的文獻資料 2 篇，最後共計 7 篇期刊符合納入標準，期刊篩選流程詳見圖 1。

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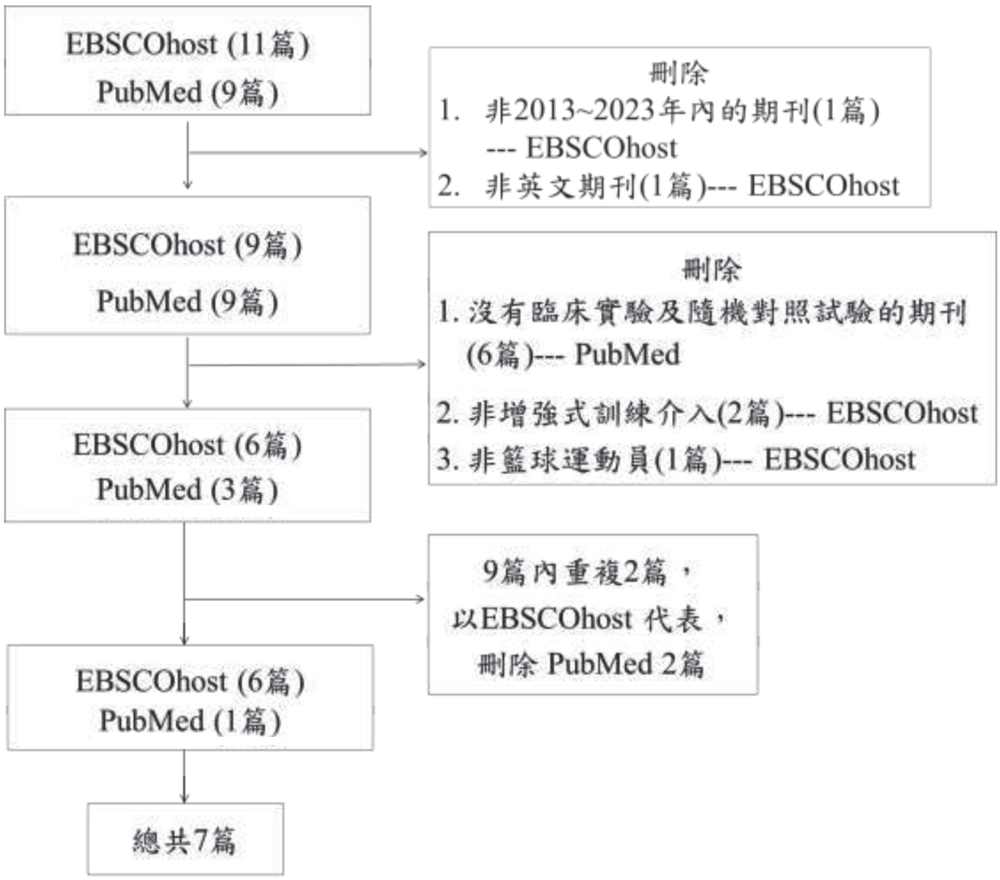
圖 1

期刊篩選流程



二、文獻統整及分類

根據參與者資料（人數、性別）、實驗設計（分組組別、各組別人數與年齡）以及介入方式（增強式訓練介入時間與方法）做出研究方法之整理，如表 1 所示，這 7 篇研究對象皆為籃球運動員，人數 12~39 人之間；平均年齡 13~22 歲；性別方面，只有女性運動員的有 1 篇、只有男性運動員有 5 篇、男女性混和有 1 篇；各組人數方面，只有 1 篇在分成 4 組的情形下各組人數在 10 人以下，有 4 篇各組 10~16 人，有 2 篇無明確說明；介入週期有 2 篇是只做一次，觀察立即效果，剩下 5 篇週期介於 3~8 週，每週頻率 2~3 次；訓練方式中，則有 2 篇有與其他訓練方式做結合，分別是平衡訓練及個別化的肌力訓練，其餘 5 篇皆為單純使用增強式訓練作為訓練，其中 1 篇有比較不同地面材質的差異。

表 2 及表 3 為這 7 篇之衝刺及敏捷性研究結果之整理，衝刺能力的測試包含 15~30 公尺的衝刺測試，敏捷能力的測試包含 Modified Illinois Change of Direction Test (MICODT)、Box Drill agility test、Modified agility T-test (MAT)、Illinois Agility Test (IAT)、Hexagon agility test、Agility T-test 及 COD test。

表 1

文獻研究方法整理

作者、年份	受試者	組別	增強式訓練介入方法內容
Bouteraa et al., 2020	26 名 U17 女性地區級 籃球運動員	1. 實驗組：n = 16 age = 16.4±0.5 y 2. 控制組：n = 10 age = 16.5±0.5 y	8 週，2 次 / 週 1. 45 分鐘（平衡訓練 30 分鐘；增強式訓練 15 分鐘），8 週內逐漸增加練習的重複次數、組數和複雜性，每週地面接觸的總數從 80 次逐漸增加到 120 次，訓練內容包含 Vertical jump-and-reach（垂直跳躍摸高）, Double leg jump forward（立定跳遠）, Double leg zig-zag jump(雙腳 Z 形跳躍）, 40 and 60 cm hurdle jump（40 及 60 公分欄架跳躍） 2. 繼續常規訓練
Ozen et al., 2020	12 名 男性 籃球運動員	age = 17.58±0.504 y 1. 沙地組 2. 木地板組 無明確說明兩組分組人數	6 週，3 次 / 週 1. 在 20 公分深的沙地上進行 2. 在 10 公分厚的木地板上進行 兩組皆使用 40 公分的增強式訓練箱和跨欄作為訓練工具，訓練內容皆包含 VJ–vertical jump（垂直跳）, SLJ - standing long jump（立定跳遠）, UCJ - unilateral countermovement jumping（單腳下蹲跳）, 180° jump, RCJ – repeated countermovement jumping（重複下蹲跳）, BJ - board jumping（來回連續立定跳）, DJ - drop jumps（著地反彈跳）
Thapa et al., 2020	12 名 男性 籃球運動員	age = 21±1.2 y 1. 實驗組 2. 控制組 12 人皆有執行實驗及控制組之介入	只做一次訓練，觀察立即效果 1. 以 box and drop jump (BDJ) 訓練，其訓練內容為： 使用 65 公分高的箱子，下蹲跳 (countermovement jump) 跳到箱子上後，再以最短的觸地時間 立即從箱子上跳下來做一個著地反彈跳 (drop jump)，進行 3 組，5 次 / 組，每次中間休息 10 秒，組間休息 60 秒。 2. 3 分鐘步行
Cengizel et al., 2022	22 名 男性 籃球運動員	1. 增強式訓練組：n = 11 age = 13.6±0.9 y 2. 跳繩訓練組：n = 11 age = 13.8±0.9 y	4 週，3 次 / 週 1. 前 2 週重複 2 輪，後 2 週重複 3 輪，增強式訓練內容包括： Single leg forward jump（單腳向前跳）, Double leg forward jump（雙腳向前跳）, Single leg side jump（單腳橫向跳躍）, Double leg side jump（雙腳橫向跳躍）, Single leg hurdle jump（單腳欄架跳躍，6 個高度為 30 公分、障礙間距離為 60 公分的欄架）, Double leg hurdle jump（雙腳欄架跳躍，6 個高度為 30 公分、障礙間距離為 60 公分的欄架） 2. 跳繩訓練介入

Munshi et al., 2022	24 名 男性 籃球運動員	age = 20.8±2.02 y 1. 增強式訓練組：n = 12 2. 全身震動訓練組：n = 12	只做一次訓練，觀察立即效果 1. double-legged vertical（雙腿垂直跳）10 次 / 組 *5, broad jumps（跳遠）15 公尺 *2, single and double legged bounding（單雙腳彈跳）30 公尺 *1, depth jumps（深度跳躍）5 次，全部從 40 公分高度完成，在 30 秒內完成 2. 全身震動訓練介入
Pinheiro Paes et al., 2022	16 名男性和 23 名女性 籃球運動員	1. 男性實驗組：n = 6 age = 15.83±0.75 y 2. 男性控制組：n = 7 age = 15.43±1.13 y 3. 女性實驗組：n = 11 age = 14.45±0.69 y 4. 女性控制組：n = 10 age = 15.30±1.16 y	3 週，2 次 / 週（週一和週三）、3 週，3 次 / 週（週一、週三和週五） 1、3：增強式訓練及籃球常規訓練 增強式訓練內容包括：CMJ（下蹲跳）, Side Jump（側向跳躍）, Horizontal Jump（跳遠）, High Knee Jump（高抬腿跳躍）, Split Squat Jump（分腿蹲跳）, Serial Forward Hops（前向跳躍）, Single Leg Vertical Jump（單腳垂直跳）, Single Leg Lateral Hops（單腳橫向跳躍） 2、4：籃球常規訓練
Barrera-Domínguez et al., 2023	30 名男性 籃球運動員	1. 介入組：n = 15 age = 22.9±6.52 y 2. 控制組：n = 15 age = 22.7±4.93 y	8 週，2 次 / 週，18 組 / 週，6 項訓練項目，每個訓練項目做 3 組 1. 根據 F-V profile (Force-Velocity Profile; 力量與速度關係) 的結果對運動員進行分類，並分成 5 組亞組，且根據每個運動員的最大重複次數 (RM) 及體重 (BW) 進行力 - 速度不平衡訓練 (force-velocity-imbalance training; F-Vimb training) 也就是將個別化的肌力訓練及增強式訓練做結合，其內容包括：Back squat（高背槓深蹲）, Deadlift trap bar（六角槓硬舉）, SL CMJ（單腳下蹲跳）, Deadlift barbell（槓鈴硬舉）, Clean pull（爆發窄拉）, CMJ trap bar（六角槓下蹲跳）, Depth jump（深跳）, SL SJ（Single Leg Squat; 單腳蹲）, Abalakov jump（擺臂垂直跳）, Band assisted CMJ（彈力帶輔助下蹲跳）, Clean pull jump（爆發窄拉跳躍）, Box jump（跳箱） 2. 接受與介入組的 well-balanced subgroup（平衡良好的亞組）進行相同訓練，但每個人都進行相同訓練量，並沒有進行個別化訓練

資料來源：本研究者整理

表 2

衝刺表現研究結果

作者、年份	衝刺測試	衝刺表現結果
Bouteraa et al., 2020	在 5、10 和 20 公尺時評估 20 公尺衝刺表現	實驗組在 3 個衝刺區間內皆無顯著訓練效果 5M：p > 0.05, d = 0.068 10 M：p > 0.05, d = 0.063 20 M：p > 0.05, d = 0.064 實驗組在 3 個衝刺區間內與控制組比較兩組並無顯著差異 5M：p = 0.87, d = 0.001 10M：p = 0.32, d = 0.02 20M：p = 0.75, d = 0.002
Ozen et al., 2020	30 M Sprint tests	兩組在組內訓練前後比較，訓練後有顯著訓練效果 ($p <$ .05) 兩組組間比較，沙地組較木地板組有顯著訓練效果 (p = 0.014)
Thapa et al., 2020	15 M linear sprint test	實驗組在組內訓練前後比較，訓練後沒有顯著效果 (p = 0.282, d = 0.245) 兩組組間比較，實驗組較控制組，兩組並無顯著差異 (p = 0.649, $\eta2$ = 0.020)
Cengizel et al., 2022	20 M sprint test	兩組在組內訓練前後比較，訓練後皆無顯著訓練效果 ($p <$ .05) 兩組組間比較，兩組並無顯著差異
Munshi et al., 2022	20 M sprint test	兩組在組內訓練前後比較，訓練後 4 分鐘或是在訓練後 12 分鐘皆無顯著訓練效果 兩組組間比較，兩組在訓練後 4 分鐘或是在訓練後 12 分鐘並無顯著差異
Pinheiro Paes et al., 2022	20 M sprint test	只比較介入前後結果 1. 男性實驗組：訓練後有顯著訓練效果 ($p <$ .05)，訓練前後改變量為 -4.15% 2. 男性控制組：訓練後有顯著訓練效果 ($p <$ .05)，訓練前後改變量為 -1.94% 3. 女性實驗組：訓練後有顯著訓練效果 ($p <$ .05)，訓練前後改變量為 -7.16% 4. 女性控制組：訓練後有顯著訓練效果 ($p <$ .05)，訓練前後改變量為 -3.02%
Barrera-Domínguez et al., 2023	10 M sprint test	介入組在組內訓練前後比較，在介入前到介入後 4 週以及介入前到介入後 8 週，有顯著訓練效果 ($p <$ 0.05)，而控制組則無顯著訓練效果 兩組組間比較，兩組在介入後 4 週，介入組較控制組有顯著訓練效果 (ES = 0.80; p = 0.02)

資料來源：本研究者整理

表 3

敏捷性表現研究結果

作者、年份	敏捷性測試	敏捷性表現結果
Bouteraa et al., 2020	Modified Illinois Change of Direction Test (MICODT)	實驗組訓練前後有顯著訓練效果 (p = 0.012，d = 0.124) 實驗組訓練後與控制組比較有顯著訓練效果 ($p <$ 0.001, d = 2.91)
Ozen et al., 2020	Box Drill agility test	兩組在組內訓練前後比較，訓練後有顯著訓練效果 ($p <$ .05) 兩組組間比較，沙地組較木地板組有顯著訓練效果 (p = 0.027)
Thapa et al., 2020	Modified agility T-test (MAT)	實驗組在組內訓練前後比較，訓練後有顯著效果 ($p <$ 0.001, d = 0.982) 兩組組間比較，實驗組較控制組有顯著訓練效果 (p = 0.006, η2 = 0.518)
Cengizel et al., 2022	1. Illinois Agility Test (IAT) 2. Hexagon agility test	1. 兩組在組內訓練前後比較，訓練後皆無顯著訓練效果 ($p <$ .05) 兩組組間比較，兩組並無顯著差異 2. 增強式訓練組在組內訓練前後比較，訓練後無顯著訓練效果 (p = 0.256)，跳繩訓練組訓練後有顯著效果 (p = 0.001, η2 = 1.32) 兩組組間比較，兩組並無顯著差異
Munshi et al., 2022	Agility T-test	兩組在組內訓練前後比較，訓練前到訓練後 4 分鐘 (p = 0.001)、訓練後 4 分鐘到訓練後 12 分鐘 (p = 0.002)、訓練前到訓練後 12 分鐘 (p = 0.001) 皆有顯著訓練效果 兩組組間比較，兩組在訓練後 4 分鐘或是在訓練後 12 分鐘並無顯著差異
Pinheiro Paes et al., 2022	Illinois Agility Test (IAT)	只比較介入前後結果 1. 男性實驗組：訓練後有顯著訓練效果 ($p <$ .05)，訓練前後改變量為 -3.65% 2. 男性控制組：訓練後有顯著訓練效果 ($p <$ .05)，訓練前後改變量為 -1.97% 3. 女性實驗組：訓練後無顯著訓練效果，訓練前後改變量為 -2.29% 4. 女性控制組：訓練後無顯著訓練效果，訓練前後改變量為 -1.12%
Barrera-Domínguez et al., 2023	COD test 1. 45°R 2. 45°L 3. 90°R 4. 90°L 5.180°R 6.180°L	控制組組內訓練前後比較，無顯著訓練效果， 介入組組內訓練前後比較，有顯著訓練效果 ($p <$ 0.05)： 1. 介入前到介入後 8 週及介入後 4 週到介入後週 2. 介入前到介入後 8 週 3. 無顯著訓練效果 4. 無顯著訓練效果 5. 介入前介入後 8 週及介入後 4 週到介入後 8 週 6. 介入前到介入後 8 週 兩組組間比較，兩組在介入後 8 週，介入組較控制組有顯著訓練效果 (ES ≥ 0.45; $p <$ 0.01)

資料來源：本研究者整理

肆、討論

表 4 為各篇研究結果比較之整理，其包括：是否結合其他運動訓練、在不同材質場地訓練、結合循環及非循環跳躍、結合單側及雙側跳躍、漸進式增加強度以及總跳躍次數進行討論。

一、結合其他運動訓練

綜合以上研究結果發現增強式訓練除了可以單獨使用，也可以與其他運動訓練做結合，例如 Bouteraa 等人進行 8 週每週 2 次的增強式訓練結合平衡訓練，對於 20 公尺衝刺能力無效果，但對敏捷性能力的提升是有明顯效果，其原因為尚須考量訓練方法上與其他研究的差異，例如，性別、年齡、運動員等級、增強式訓練的形式、頻率、持續時間等；在 Barrera-Domínguez 等人進行 8 週每週 2 次的增強式訓練結合個別化肌力訓練對於衝刺及敏捷性能力的提升都是有明顯效果的，但衝刺能力卻比敏捷性能力更早得到顯著的訓練效果，即衝刺能力在介入前到介入後 4 週即得到效果，而敏捷性能力則是在介入後 4 週到介入後 8 週及介入前到介入後 8 週才得到訓練效果，其原因是增強式訓練的特異性可幫助改善神經協調性，且垂直方向的力量對衝刺速度的相關性是更大的。關於敏捷性能力的改善，其認為與 COD 及 F-Vimb training 之間的高相關性有關，且 COD 表現的決定性因素也與反應力量指數 (reactive strength index; RSI) 有關。因此建議，要單獨提升敏捷性能力，可將增強式訓練與平衡訓練做結合，而若要增強衝刺及敏捷性兩者，則可將增強式訓練及個別化肌力訓練結合以達到訓練效果。

二、不同材質場地訓練

在 Ozen 等人的研究裡指出不管是在沙地還是木地板進行訓練，對於衝刺及敏捷性能力提升都有明顯效果，但是沙地的訓練效果又顯著高於木地板，因為增強式訓練在沙地或較柔軟的地面訓練時，會使彈性能減少，以及腳踝難以沿著垂直軸推動身體，而導致產生的力量被吸收，因此需要產生更強的向心收縮才能推動身體。且在沙地運動時會產生更多的生理負荷，而產生更多的肌力和耐力。因此建議可在沙地或柔軟地面進行增強式訓練，以提升衝刺及敏捷性能力。

表 4
各篇研究結果比較

比較項目 / 作者年份	結合其他運動訓練	不同材質場地訓練	循環、非循環跳躍	單側、雙側跳躍	漸進式、非漸進式增加強度	總跳躍次數	衝刺能力結果		敏捷性能力結果	
							組內比較	組間比較	組內比較	組間比較
Bouteraa et al., 2020	結合平衡訓練		結合	只有雙側	漸進式	1588 下（8 週，2 次 / 週）	實驗組無效果	兩組無差異	實驗組有效果	實驗組較控制組有效果
Ozen et al., 2020		沙地 vs. 木地板	結合	結合	漸進式	1890 下（6 週，3 次 / 週）	沙地組及木地板組皆有效果	沙地組較木地板組有效果	沙地組及木地板組皆有效果	沙地組較木地板組有效果
Thapa et al., 2020			只有循環	只有雙側	只做一次訓練，觀察立即效果	因只進行一次訓練，故不參與比較	實驗組無效果	兩組無差異	實驗組有效果	實驗組較控制組有效果
Cengizel et al., 2022			只有循環	結合	漸進式	3060 下（4 週，3 次 / 週，前 2 週重複 2 輪，後 2 週重複 3 輪）	增強式訓練組無效果	兩組無差異	增強式訓練組無效果	兩組無差異
Munshi et al., 2022			結合	結合	只做一次訓練，觀察立即效果	因訓練項目內容以距離計算，故不參與比較	增強式訓練組無效果	兩組無差異	增強式訓練組及全身震動訓練組皆有效果	兩組無差異
Pinheiro Paes et al., 2022			結合	結合	漸進式	1140 下 [3 週，2 次 / 週（週一和週三）、3 週，3 次 / 週]	男性及女性之實驗組及控制組皆有效果	無比較	男性之實驗組及控制組皆有效果女性之實驗組及控制組皆無效果	無比較
Barrera-Domínguez et al., 2023	結合個別化肌力訓練		只有非循環	結合	強度計算方式與其他文獻方式不同，故不參與比較	跳躍次數計算方式與其他文獻方式不同，故不參與比較	介入組有效果	介入組較控制組有效果	介入組有效果	介入組較控制組有效果

資料來源：本研究者整理

三、循環、非循環跳躍結合

非循環跳躍是指在一次跳躍之後，在下一次跳躍之前有短暫的休息，大約 5 秒左右的休息時間，而循環跳躍則相反，每次跳躍之間持續執行，沒有組間休息時間 (Aztarain-Cardiel et al., 2023)。表 4 整理出各篇期刊是否結合循環及非循環跳躍，和衝刺及敏捷性經過訓練後之結果。

依照表 4 整理的資訊裡可得知，有 2 篇循環及非循環跳躍結合的研究 (Bouteraa et al., 2020; Ozen et al., 2020; Pinheiro Paes et al., 2022) 可在衝刺能力得到訓練效果；只有非循環跳躍的研究 (Barrera-Domínguez et al., 2023) 雖顯示有訓練效果，但僅 1 篇期刊，因此無法斷定有結合或只有循環，或只有非循環跳躍何者的訓練效果佳；而關於敏捷性能力不論是否結合，顯示的結果正反向皆有，例如在 Pinheiro Paes 等人的研究裡顯示只有男性實驗組有訓練效果女性實驗組則無，可能為神經適應造成的訓練效果，因增強式訓練可以促進更多運動單位的募集和改善肌肉間的協調。

四、單側、雙側跳躍結合

單側跳躍的增強式訓練是使用單腳進行，雙側跳躍是雙腳同時進行。

依照表 4 整理的資訊裡可得知在雙側跳躍增強式訓練的研究裡，對於 Bouteraa 等人及 Thapa 等人的研究對衝刺能力是無訓練效果，敏捷性能力是有效果的，而會有此現象，其可能為 15 m 衝刺測試之前進行了 2 次敏捷性的測試 (MAT)，而產生疲勞導致衝刺能力沒有訓練效果，另一種可能原因是在經過 BDJ 訓練計畫後，只有 3 分鐘的休息時間，不足以達到身體完整恢復就進行測試。日後的研究至少在訓練後需休息 8~12 分鐘使受測者得到充分休息，才能使測試結果更加準確 (Winwood et al., 2016)。

在結合單側及雙側跳躍訓練的研究裡對敏捷性能力的提升相較於衝刺能力，是有較大的效果，在單雙側結合的 5 篇研究有 4 篇對於敏捷性能力提升有顯著效果 (Barrera-Domínguez et al., 2023; Munshi et al., 2022; Ozen et al., 2020; Pinheiro Paes et al., 2022)，但衝刺能力只有 3 篇有顯著效果 (Barrera-Domínguez et al., 2023; Ozen et al., 2020; Pinheiro Paes et al., 2022)，因此若要提升敏捷性能

力，可將單雙側的增強式訓練適時結合，以達到良好的訓練效果。

五、漸進式增加強度

漸進式增強是每次訓練或每週訓練漸進式增強，而非依照第 1 週訓練強度或只做一次訓練。

在有漸進式增加強度的研究裡有 3 篇 (Bouteraa et al., 2020; Ozen et al., 2020; Pinheiro Paes et al., 2022)，對於衝刺及敏捷性的訓練結果中有顯著訓練效果，而 Cengizel 等人研究則沒有顯著效果，其原因是在無介入增強式訓練之前，平時訓練當中，即可增加衝刺及敏捷性能力，所以在此次研究中無明顯訓練效果。因此建議，增強式訓練的強度可採漸進式增強以提高衝刺及敏捷性的訓練效率。

而在 Thapa 等人及 Munshi 等人的研究裡，其強度皆只做一次訓練，觀察立即訓練效果，而兩者的結果也是一致的，對於衝刺能力無訓練效果，對於敏捷性能力則皆有顯著訓練效果，因此若是只有增加敏捷性能力的需求，可介入即時性的增強式訓練處方。

六、總跳躍次數

在總跳躍次數裡，除了 2 篇只做一次訓練，觀察立即訓練效果 (Munshi et al., 2022; Thapa et al., 2020) 及跳躍次數計算方式與其他文獻方式不同 (Barrera-Domínguez et al., 2023) 的研究，針對其餘 4 篇 (Bouteraa et al., 2020; Cengizel et al., 2022; Ozen et al., 2020; Pinheiro Paes et al., 2022) 的總跳躍次數進行比較，這 4 篇的總跳躍次數由少到多分別是 1140、1588、1890 及 3060 下，結果發現，總跳躍次數在 1140、1890 下皆可同時增加衝刺及敏捷性能力，1588 下可增加敏捷性能力，而 3060 下反而無明顯訓練效果。而 3060 下無明顯訓練效果之原因，是因其受測者納入標準為有定期參與增強式訓練者，在研究計畫介入前就已增強衝刺及敏捷性能力，所以在介入後才無明顯訓練效果。若想同時增加衝刺及敏捷性能力，需接受總跳躍次數至少 1140 下，方可取得良好的訓練效果。

伍、結 語

根據本篇文獻回顧結果，可以得知增強式訓練內容的不同，對於籃球運動員衝刺及敏捷性能力提升是有影響的，經由本篇研究可得知：

一、欲單獨提升衝刺能力，可將循環及非循環跳躍增強式訓練結合。

二、欲單獨提升敏捷性能力，可結合增強式與平衡訓練、結合單側及雙側跳躍增強式訓練。

三、須及時提升敏捷性能力，可參考只做一次訓練，觀察立即訓練效果的增強式訓練處方。

四、須同時提升衝刺及敏捷性兩者的能力，可結合增強式及個別化肌力訓練、在沙地或柔軟地面進行增強式訓練、漸進式增加強度以及接受總跳躍次數至少 1140 下。

本篇研究以文獻回顧的方式完整搜尋、整理及討論，但仍因搜尋的關鍵字而無法比較其餘無搜尋到的期刊文獻，而存在研究限制，包含無法比較除了沙地及木地板以外的地面材質、單純使用循環及非循環跳躍的比較，以及單純使用單側及雙側跳躍的比較，因此，建議未來可針對上述之研究限制，進行更進一步的研究，以更加完整的針對籃球運動員，給出最適當的增強式訓練方案。

經由本篇研究結果得知，為了使籃球運動員提升賽場上衝刺及敏捷性能力表現，建議在進行增強式訓練時，可結合個別化肌力訓練，且在沙地或柔軟地面進行漸進式增加強度且總跳躍次數至少 1140 下的訓練處方，以提升衝刺及敏捷性能力。

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The Influence of Plyometric Training on Basketball Players' Sprints and Agility: a scoping review

Tzu-Ling Chen, Chih-Yang Taun
Department of Exercise Health Science, National Taiwan University of Sport

Abstract

Basketball is a team sport that demands high levels of intensity. It requires players to perform physical activities such as jumping, sprinting, and changing of direction abilities. Some previous researches have shown that plyometric training can increase short-term muscle strength and improve sprints speed. The features of plyometric training can also reduce the muscle reaction time and thereby facilitate agility. Besides technical and tactical skills, it is crucial for basketball players to develop sprints and agility. However, there have been contradictions and limitation in the previous research on plyometrics training while the training methods and contents are inconsistent. To address the issues, this study conducted a scoping review focusing on basketball players' adoption of plyometrics training to determine the positive impact on sprints and agility. This study also organized the methods of effective training. Finally, the results showed that basketball players could improve their sprints and agility by individualizing strength training that was combined with plyometrics training and progressively increasing training intensity to at least 1140 repetitions on sandlots or soft ground.

Keywords: basketball, plyometrics training, basketball performance

Predict the Winning Ratio of Major League Baseball Teams: Generalized Pythagorean Formula Approach

Hsiao Chiu-Ming
Department of Finance, National Yunlin University of Science and Technology

Abstract

This study investigates the winning ratio of Major League Baseball (MLB) season games by using a generalized Pythagorean formula. Based on the method of regression analysis, this study verifies the ability of the generalized Pythagorean formula to predict MLB team winning rates. Empirical results show that the multivariate regression model has a highest adjusted R2 (0.9126) than other regression models. In addition, either MSE or MAE of in-sample and out-of-sample, the generalized Pythagorean formula derived from Cobb-Douglas production function has the lowest values than other versions of Pythagorean formula. Based on this generalized Pythagorean formula, team's managers can acquire potential rookies through drafts or player trades to recruit the players they need to achieve the team's goals.

Keywords: Pythagorean formula for baseball, Cobb-Douglas function, win-loss ratio

Corresponding author: Hsiao Chiu-Ming
E-mail: shiaucm@yuntech.edu.tw
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1. Introduction

To estimate the expected winning percentage of baseball team, Bill James, the pioneer sabermetrician, has developed a basic formula based on the runs scored and runs allowed (Yoon and Choi, 2022). This is a more statistically sound way to evaluate a team's performance than just looking at their actual wins and losses. Over the long run, he has found that a team's runs scored and runs allowed are strong indicators of their performance.

In addition, the Pythagorean expectation formula is also used in other sports and fields to assess team performance (Boudreaux, Ehrlich, Ghimire, and Sanders, 2021; Chen and Li, 2016; Cochran and Blackstock, 2009; Dayaratna and Miller, 2013; Sarlis and Tjortjis, 2020; Senevirathne and Manage, 2021). In essence, it's a simple yet powerful way to quantify the relationship between scoring runs and preventing runs in sports where the objective is to outscore the opponent.

Beside the Pythagorean formula for baseball, analysts and fans use other formulae to evaluate teams' performances and to identify those that might be over-performing or underperforming relative to their underlying statistics, such as, Hsiao, Zhang, Chen, and Chung, (2022) employs the probit model to estimate the win-loss ratio of NBA teams, meanwhile, Hsiao, Chou, Lin, Lin, Tsao, and Wang (2023) employs multivariate logit regression model to estimate the game's results of football teams in English Premier League. The formulae can help assess whether a team is likely to maintain its success (Sarlis and Tjortjis, 2020).

Although the Pythagorean expectation formula is useful and easily to understand, however, it also has some drawbacks. Since it is too simple to estimate the expected win-loss ratio such that it does not account for other factors, such as, luck, injuries, weather conditions, and other external variables which may affect a team's performance. Therefore, this study tries to develop a generalized Pythagorean formula to estimate the win-loss ratio.

The generalized Pythagorean formula in this study has the following improvements. First, the exponents of runs scored and runs allowed are not necessarily equal, which is different from previous versions of Pythagorean formula. Second, due to some non-quantitative factors affecting the team's winning rate, such as the aforementioned player suspension due to injury, players transfer team mid-season, mistakes, etc. Therefore, in the setting of the generalized Pythagorean formula, there is a constant K to capture the impact of this non-quantitative factor. Third, by setting a Cobb-Douglas production function to model the win-loss ratio, a generalized Pythagorean formula can be deduced. Therefore, the estimates of exponents for runs scored and runs allowed can be estimated through econometric models in Economics. Such that, either the original version or modified version of Pythagorean formula, the drawback of equal exponent assumption can be corrected. Finally, according to the derivation process of the generalized Pythagorean formula, the factors that affect the win-loss ratio can be extended. In other words, beside the original runs scored and runs allowed, some other factors can be added into the model if the factors have impact on the team's win-loss ratio (Mizels, Erickson, and Chalmers, 2022; Valero, 2016). That is to say, the generalized Pythagorean formula is extensible (Zech, 1981).

The structure of this study is as follows: Chapter 2 is the methodology that introduces the model setting and mathematical derivation of the generalized Pythagorean formula. Chapter 3 shows the empirical results of both regression and Pythagorean formulae. According to Yoon and Choi (2022), the assessments of several versions of Pythagorean formula are the mean squared errors (MSE) and mean absolute errors (MAE) and the assessment results are shown own in Chapter 4. The discussion and implications part is in the Chapter 5. In this chapter, this study will explore the theoretical implications of the generalized Pythagorean formula and try to put forward some management implications based on the empirical results. Final, Chapter 6 is the conclusion of this study.

2. Literature Review

In Jang, Lee, and Fort (2019), it explores the statistical properties of the winning ratios for nine major sports leagues around the world. Some are distributed as normal with higher kurtosis and some are skew which is abnormal. Furthermore, in accordance to Cefis (2023), data science is applied in several areas of daily life and there have been many applications to sports. Such that, the big data analysis can also be used in the professional sports management. Moreover, as shown in Baumer, Matthews, and Nguyen (2023), sports analytics has broadly defined as the pursuit of improvement in athletic performance through the analysis of data and has expanded its footprint both in the professional sports industry and in academia since 1980s.

From the movie “Moneyball”, the Oakland Athletics, under the leadership of manager Billy Beane, won a record of 102 wins and 60 losses, in the 2001-02 season (Elitzur, 2020). And the team owner spent only $34 million to pay the players’ salary, which was lower than either the New York Yankees or Texas Rangers that year, which salary are above of $100 millions of dollars. Such that, it can be regarded as a sign of high capital efficiency. In Lewis (2003), a baseball team’s analytical and statistical performance to the cost of capital are discussed first. Hereinafter, Hakes and Sauer (2006) extended Lewis’ approach by providing more empirical evidence that supports the claim that a baseball team’s performance goes beyond the box score output. Rosenfeld, Fisher, Adler, and Morris (2010) estimated the winning ratio of NBA, NFL and MLB teams by using the Pythagorean formula for the overtime games. They found that if a team has a 75% chance of winning a full-length game, its chances of winning an overtime game is 63% for the MLB. In addition, Joseph (2019) implements statistical examinations of winnings for the North American professional sports.

Beside the statistical approach, Yoon and Choi (2022) also implements mathematical approach to derive the Pythagorean formula for MLB. Traditionally, there are two approaches to estimate the Pythagorean exponent: (1) statistical approach by assuming runs scored and runs allowed to be randomized (Chen and Li, 2016; Dayaratna and Miller, 2012; Ehrlich, Boudreaux, Boudreau, and Sanders, 2020; Heumann, 2016; McGoldrick and Voeks, 2005; Miller, 2007; Miller, Corcoran, Gossels, Luo, and Porfilio, 2014; Rothman, 2014); and (2) mathematical approach for calculating the Pythagorean exponent (Lee, 2014; Yoon and Choi, 2022). In this study, runs scored and runs allowed can be regarded as economic inputs, and their output is the team's odds ratio of win-loss. Such that, the exponents of these two inputs can be estimated using the Cobb-Douglas production function.

Furthermore, in order to verify the validation of the generalized Pythagorean formula, this study also introduces the model evaluation method of Yoon and Choi (2022) to compare various versions of the Pythagorean formula with the estimation results of regression models, including ordinary least squares (OLS), two-stage regression, and Poisson regression. OLS is an estimation of multivariate regression models that can be used to estimate which factors are significant to a team's winning ratio and their loadings. However, when there is a high degree of correlation among many influencing factors, there may be multicollinearity among these variables. This can even cause the original estimated values of individual parameters to be unstable and the standard errors to be too large (Greene, 2018; Wen and Chiou, 2009). Therefore, this study also introduces the two-stage regression method to investigate the nexus between winning ratio and the explanatory variables. Firstly, regress the home winning ratio on some highly correlated variables. Secondly, after calculating the residuals of this part, and then add it with other variables to the explanatory variables to regress to the winning ratio.

Since the number of wins in the entire season is a positive integer, such that, the winning ratio of the season can be estimated by estimating the number of wins of the team. For this reason, this study further introduces the Poisson regression model which is used to explain the dependent variable when it is a counting number to investigate the nexus between wins and other explanatory variables.

2.1 Basic Pythagorean formula

First, consider the original Pythagorean formula for baseball proposed first by James (1980). The basic Pythagorean formula for the win-loss ratio (WCPT) is given by

$$WCPT_{James2} \equiv \frac{\left(S/_{GP}\right)^2}{\left(S/_{GP}\right)^2 + \left(A/_{GP}\right)^2}, \tag{1}$$

where, S and A represent the total runs scored and total runs allowed of the team, respectively; GP is the games played in the season. A corrected version in Valero (2016) is given as follows:

$$WCPT_{James183} \equiv \frac{\left(S/_{GP}\right)^{1.83}}{\left(S/_{GP}\right)^{1.83} + \left(A/_{GP}\right)^{1.83}}. \tag{2}$$

In addition, Ehrlich et al. (2020) used simulated MLB game results and estimated the exponent to be 1.722. However, Boudreaux et al. (2021) used MLB data from the 2003 season to the 2015 season to estimate the exponent at 1.859. This study will compare the results predicted by these methods with that of the generalized Pythagorean formula empirically by using the MLB data from season 2013 to season 2022.

2.2 Miller's Pythagorean formula

Next, Miller (2007) developed a modified version of the James' Pythagorean formula using a Weibull distribution specification of the win-loss ratio. The Miller's Pythagorean formula for the win-loss ratio is given as follows:

$$WCPT_{Miller} \equiv \frac{\left(S/_{GP} - \theta\right)^{\gamma}}{\left(S/_{GP} - \theta\right)^{\gamma} + \left(A/_{GP} - \theta\right)^{\gamma}}, \tag{3}$$

for some parameters θ and γ.

The Miller's version of Pythagorean formula is based on the assumption that runs scored and runs allowed are random variables distributed as Weibull distribution (Miller et al., 2014). However, it is not easy to estimate the parameters of such an exquisite probability distribution. Therefore, it is not easy to estimate the team's win-loss ratio.

In order to simplify the complex calculations of the Miller's version, some modified versions set the parameter θ in the Miller's version of the Pythagorean formula to 0. For example, David Smyth, who invented the base runs (BsR), uses $\theta = 0$ and $\gamma = \left(\frac{S+A}{GP}\right)^{0.287}$; Clay Davenport, a co-founder of Baseball Prospectus (BP), employed $\theta = 0$ and $\gamma = 0.45 + 1.5 \times \ln\left(\frac{S+A}{GP}\right)$.

Furthermore, Lee (2015) used Korean Professional Baseball data from the 2004 season to the 2013 season to estimate an exponent higher than MLB. Moreover, in the Lee's empirical result, the exponents of runs scored and runs allowed are significantly unequal. This result implies that the exponents of runs scored and runs allowed may not be the same value.

2.3 Generalized Pythagorean formula

Aforementioned, the exponents of runs scored and runs allowed in the modified versions of the Pythagorean formula are set to be equal. It can be thought that the runs scored and runs allowed are equally weighted to the winning ratio. As Sun Bin, the greatest Chinese military strategist, said that team is skillful in attack whose opponent does not know what to defend; and it is skillful in defense whose opponent does not know what to attack. In the sports, every score can be regarded as a display of the overall offensive results of an individual or a team (Jones and Tappin, 2005); and every point lost can also be thought as the price paid for a defensive failure (Jones and Tappin, 2005; Heumann, 2016).

Furthermore, the integration of offense and defense is an important factor for a team to win. Attack and defense cannot be partial to either side. As indicated in Porter and Scully (1982), the baseball team's winning ratio is related to team's hitting performance and team's pitching performance. Based on the model of Porter and Scully (1982), the performance of team's managers can be evaluated, although Ruggiero, Hadley, Ruggiero and Knowles (1998) does not think so. In this study, some correction should be made including the performance of team, the factors which affect the performance and their corresponding exponents.

First, according to Scully (1974), the team performance is an important measure for the managers who take some strategies to manage the team. In the past, most of the research on winning ratio focused on the econometric models, with less discussion of its theoretical basis (Dayaratna and Miller, 2016). However, recently, win-loss ratio has been the research topic not only because it can represent the performance of the team, but also has some economic implications of the model by setting the Cobb-Douglas production function of the win-loss ratio.

Second, Cochran and Blackstock (2009) investigates the winning ratio of National Hockey League (NHL) by using modified Pythagorean formula which allows for different values of the exponents in the three positions of the formula. Such that, as indicated in Zech (1981), consider the following Cobb-Douglass production function (Cobb and Douglas, 1928) for the win-loss ratio:

$$\frac{WCPT_G}{1-WCPT_G} = f\left(\frac{S}{GP}, \frac{A}{GP}\right) \equiv K \cdot \left({}^{S}/_{GP}\right)^{\alpha} \cdot \left({}^{A}/_{GP}\right)^{\beta}, \quad (4)$$

for some constants α, β, and K is positive. Then eq. (4) can be transformed into

$$K \cdot \left({}^{S}/_{GP}\right)^{\alpha} \cdot \left({}^{A}/_{GP}\right)^{\beta} - K \cdot \left({}^{S}/_{GP}\right)^{\alpha} \cdot \left({}^{A}/_{GP}\right)^{\beta} \cdot WCPT_G = WCPT_G. \quad (5)$$

Such that,

$$WCPT_G \equiv \frac{K \cdot \left({}^{S}/_{GP}\right)^{\alpha} \cdot \left({}^{A}/_{GP}\right)^{\beta}}{1 + K \cdot \left({}^{S}/_{GP}\right)^{\alpha} \cdot \left({}^{A}/_{GP}\right)^{\beta}}. \quad (6)$$

As a result, it can be rewritten into

$$WCPT_G = \frac{K \cdot \left({}^{S}/_{GP}\right)^{\alpha}}{K \cdot \left({}^{S}/_{GP}\right)^{\alpha} + \left({}^{A}/_{GP}\right)^{-\beta}.}. \quad (7)$$

Hence, the generalized Pythagorean formula for the expected winning ratio can be found in the above equation.

Moreover, according to the Cobb-Douglas form of win-loss, then the logarithmic win-loss ratio is given as follows:

$$\ln\left(\frac{WCPT_G}{1-WCPT_G}\right) = \ln K + \alpha \cdot \ln\left(S/_{GP}\right) + \beta \cdot \ln\left(A/_{GP}\right), \quad (8)$$

such that, the constants in the model can be estimated by using a double-log linear regression and historical data.

Therefore, as Yoon and Choi (2022), based on the mean square errors (MSE) and mean absolute errors (MAE), this study compares the results of various predictions of MLB team winning rates, including three regression models and four main versions of the Pythagorean formula.

3. Empirical Results

3.1 Data collection and descriptive statistics

Since the MLB regular season games is the main object to study, such that the empirical data is downloaded from the MLB official website (https://www.mlb.com/stats/team). The full data period is from 2013 to 2022 for the 30 teams in MLB. Based on the data, this study establishes six models to fit the data and then uses to make in-sample prediction of winning ratio and out-of-sample forecasting of 2023 game results.

In this study, *WinRatio* and *HomeWR* represent the total winning ratio and winning ratio at home court, respectively. *WinRatio* is the dependent variable and defined as the ratio of wins and games played in the season. *HomeWR* is defined as the ratio of wins and games played at home curt. In addition, RS and RA are the runs scored and allowed, respectively. *ERA* is the average number of earned runs a pitcher allows per 9 innings. *AVG* is the rate of hits per bat. *GO2AO* is the ratio of groundout to air out. *SO9* is the strikeout rate per 9 innings and *K2BB* is the strikeout to walk rate. The following table shows the descriptive statistics of the variables.

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Table 1

The descriptive statistics of variables (Data period: 2013 to 2022)

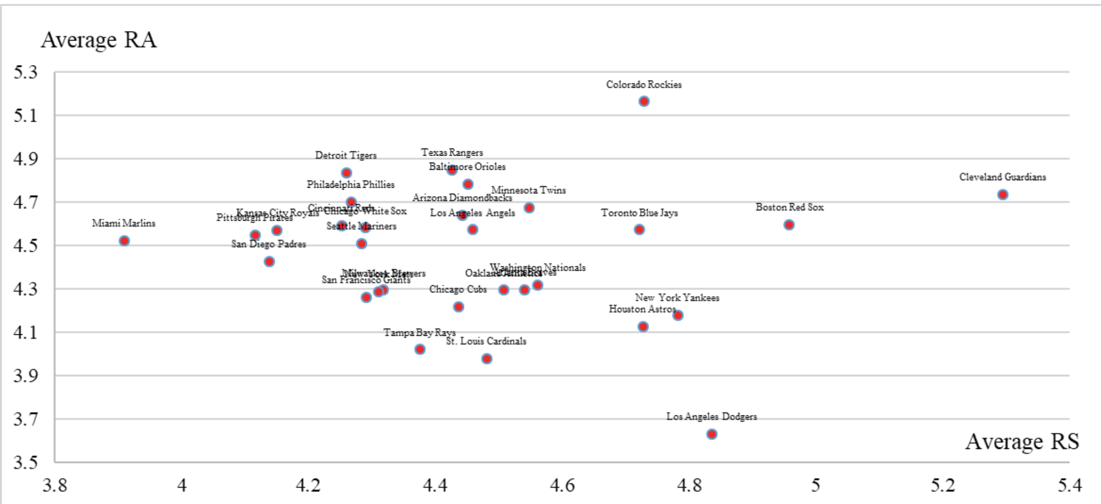
Variable	Observations	Mean	Std. Dev.	Median	Min	Max
WinRatio	300	0.5003	0.0798	0.50	0.2901	0.7167
HomeW	300	0.5393	0.1022	0.54	0.2733	1.3333
RS	300	4.4596	0.6554	4.41	3.1667	11.9500
RA	300	4.4609	0.7212	4.38	3.1667	12.1667
ERA	300	4.1416	0.5745	4.07	2.8000	5.8400
AVG	300	0.2499	0.0147	0.25	0.2070	0.2830
GO2AO	300	1.0350	0.1267	1.02	0.7800	1.5100
SO9	300	8.3383	0.8550	8.29	6.1100	10.9800
K2BB	300	2.6654	0.4432	2.60	1.7600	3.9800

Data source: MLB official website (https://www.mlb.com/stats/team/).

Table 1 shows that the average value (median) of *WinRatio* is 0.5003 (0.50), half-and half winning ratio MLB teams. In addition, the average value (median) of *HomeWR* is 0.5393 (0.54), slightly higher than 0.5, which means that the home-court advantage is valid but insignificant statistically. Moreover, the average values of runs scored *(RS)* and runs allowed *(RA)* are almost equal. In other words, the average offensive and defensive performance are almost the same.

Figurer 1

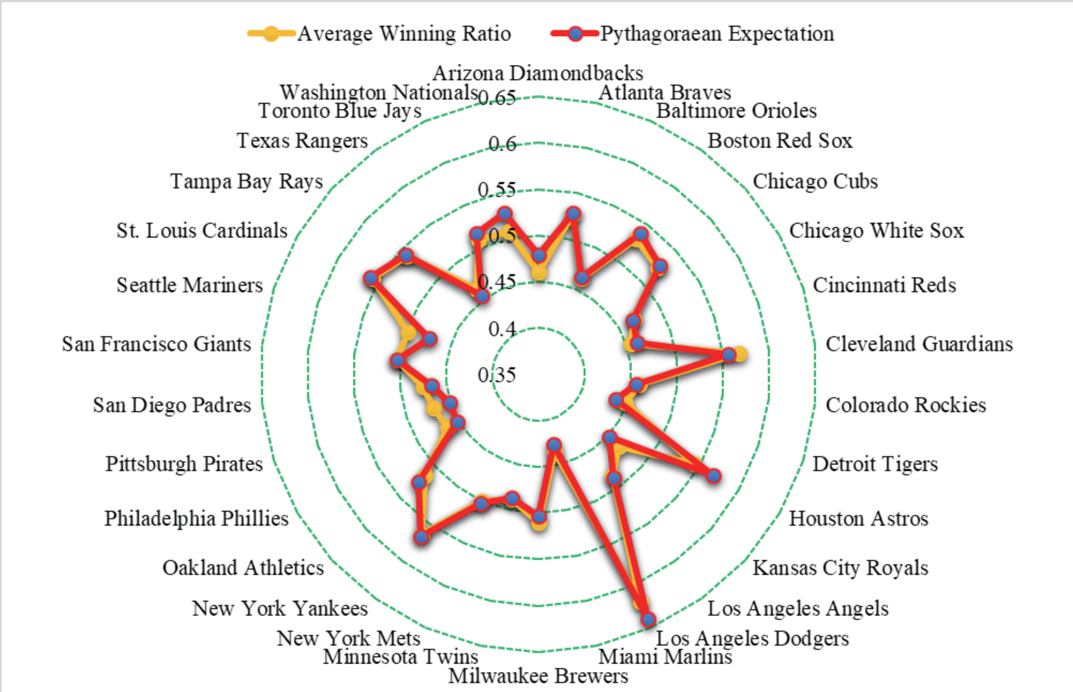
Distribution of average runs scored and average runs allowed (2013-2022)



On average, Figure 1 shows that Los Angeles Dodgers has the lowest runs allowed while Colorado Rockies has the highest runs allowed. In addition, Cleveland Guardians has the highest runs scored, however, Miami Marlins has the lowest runs scored.

Figure 2

Average winning ratio and average Pythagorean expectation (2013-2022)



In Figure 2, the Pythagorean expectations (in red) of each team follow the same pattern as their average winning ratios (in yellow). Moreover, the two values for each team are also almost the same. It indicates that the Pythagorean expectation may be an indicator for the team's winning ratio. This result is coincide with James (1980).

Table 2

The pairwise correlation coefficients of variables

	WinRatio	*Home*	*RS*	*RA*	*ERA*	*AVG*	*GO2AO*	*SO9*
HomeW	0.8220***							
RS	0.4984***	0.6587***						
RA	-0.5573***	-0.1953***	0.3697***					
ERA	-0.0243	0.0205	-0.0351	-0.0066				
AVG	-0.0037	0.0696	0.0999*	0.0716	0.7450***			
GO2AO	-0.1113*	-0.0660	-0.0103	0.0840	-0.1651***	0.0944		
SO9	0.0253	-0.0423	-0.1297**	-0.114*	-0.2360***	-0.6279***	-0.1189**	
K2BB	0.0554	0.0130	0.0121	-0.0244	-0.6770***	-0.6443***	-0.0056	0.6183***

Note: *, ** and *** are represented the significant level of 10%, 5% and 1%, respectively. Data period is from 2003 to 2022 downloaded from MLB official website.

Table 2 shows that the *WinRatio* is significantly positively correlated to runs scored *(RS)* and negatively correlated to runs allowed *(RA)*. This result supports to the definition Pythagorean formula proposed by James (1980). Such a phenomenon also appears in *HomeWR*.

3.2 The multivariate regression results

For the regression models, this study will employ the backward reduction method to eliminating the variables from the full regression model when the parameter estimate is statistically insignificant (p-value is larger than 10%).

3.2.1 Linear regression

According to Rothman (2014), a linear regression model is considered as follows:

$$WinRatio = \alpha + \gamma_1 \cdot HomeWR + \beta_1 \cdot RS + \beta_2 \cdot RA + \gamma_2 \cdot SO9 + \varepsilon, \quad (9)$$

where, ε is the random error. The estimating results are shown in the following table.

Table 3
The estimation result of multivariate regression model

Variable	*WinRatio*
HomeW	0.2153***
	(9.38)
RS	0.0713***
	(18.84)
RA	-0.0792***
	(-30.07)
SO9	0.0031*
Constant	0.3938***
	(20.11)
Observations	300
Adj.	0.9126
Mean VIF	2.28

Note: The value in parentheses is the t-value of the parameter estimate. *, ** and *** are represented the significant level of 10%, 5% and 1%, respectively.

In Table 3, RS and RA have significantly effect on the winning ratio, however, they are in different direction. Moreover, the null hypothesis: $|\beta_1| = |\beta_2|$ is not rejected with p-value 0.23, that is, the absolute value of loadings of RS and RA are statistically insignificantly different. This result is coincide with the result of Rothman (2014).

3.2.2 Two-stage regression

As shown in Table 2, there are significantly correlated relationship between *HomeWR* and RS, RA. In accordance with Greene (2018), when there is a high degree of correlation between variables, the accuracy of the estimation of the regression coefficients may be reduced, making the variation larger and the estimation less stable. To reduce the effect of high correlation between variables in the regression model, Yang and Swartz (2004) proposed a two-stage regression method to predict the winning ratio. Such that, the first stage is to regress *HomeWR* by using the following equation:

$$HomeWR = c_0 + c_1 \cdot RS + c_2 \cdot RA + \epsilon_H, \quad (10)$$

where, ϵ_H is random error.

Using the result in the first stage, the estimated $HomeWR$ is given in the following

$$\widehat{HomeWR} = 0.2719851 + 0.1319986 \times RS - 0.0720253 \times RA, \tag{11}$$

and the residuals can be found as follows:

$$HomeWRErr = HomeWR - \widehat{HomeWR}. \tag{12}$$

Next, the second stage regression model is given as follows:

$$WinRatio = \alpha + \beta_1 \cdot RS + \beta_2 \cdot RA + \delta \cdot HomeWRErr + \varepsilon. \tag{13}$$

The following table shows the estimating results of the second stage regression.

Table 4

The estimation result of two-stage regression model

Variable	***WinRatio***
RS	0.0993***
	(43.85)
RA	-0.0950***
	(-46.16)
Home	0.2162***
	(9.38)
Constant	0.4812***
	(43.99)
Observations	300
Adj.	0.9109
Mean VIF	1.11

Note: The value in parentheses is the t-value of the parameter estimate. *, ** and *** are represented the significant level of 10%, 5% and 1%, respectively.

As shown in Table 4, the estimates of RS and RA are 0.0993 and -0.0950, respectively. Such that, the null hypothesis: β_1=-β_2 is not rejected with the *p*-value 0.46. This result supports the assumption of all versions of Pythagorean formula, except the generalized one.

3.2.3 Poisson regression result

Since the wins of a regular season are always counting numbers, such that, a

Poisson regression model can also be employed to estimate the team's wins (Hsiao, 2022). As described in Greene (2018), the Poisson regression model is given as follows:

$$\ln E[Wins|\boldsymbol{X}] = \beta_0 + \boldsymbol{X} \cdot \boldsymbol{\beta}, \quad (14)$$

with the likelihood function of Poisson distribution:

$$\Pr[Wins = n|\boldsymbol{X}] = \frac{e^{-\lambda(\boldsymbol{X})} \cdot [\lambda(\boldsymbol{X})]^n}{n!}, n \in \mathbb{N} \cup \{0\}. \quad (15)$$

Hence, the estimating results of Poisson regression are shown in the following table.

Table 5

The estimation result of Poisson regression model

Variable	***WinRatio***
WinsHome	0.0272***
	(28.53)
RS	-0.0386***
	(-2.96)
RA	-0.0146
	(-1.11)
Constant	3.4235***
	(44.80)
Observations	300
Pseudo	0.4238

Note: The value in parentheses is the z-value of the parameter estimate. *, ** and *** are represented the significant level of 10%, 5% and 1%, respectively.

Hence, the expected wins of the team can be estimated by the following equation:

$$\widehat{Wins} = e^{3.4235+0.0272\times HomeRatio-0.0386\times RS-0.0146\times RA}, \quad (16)$$

and the expected winning ratio is given as follows:

$$\widehat{WinRatio} = \widehat{Wins} \div GP, \quad (17)$$

where, *GP* represents the total games played in the regular season.

3.3 Pythagorean formulae

3.3.1 Miller's Pythagorean formula

As in the definition of James' Pythagorean formula (Winston, Nestler, and Pelechrinis, 2022), the expected win-loss ratio is given as follows:

$$\frac{WCPT}{1-WCPT} = \left(S/_{A}\right)^{2}. \tag{18}$$

Such that, the logarithmic value of expected win-loss ratio can be found by

$$\ln\left(\frac{WCPT}{1-WCPT}\right) = 2 \cdot \ln\left(S/_{A}\right), \tag{19}$$

Furthermore, the following regression model can be used to estimate the exponent of the runs scored:

$$\ln\left(\frac{WinRatio}{1-WinRatio}\right) = \beta \cdot \ln\left(S/_{A}\right) + \epsilon. \tag{20}$$

The estimate of the above regression equation is $\hat{\beta} \doteqdot 1.766423$ with standardized error 0.0367 for the MLB regular games from 2013 to 2022. It is different to the value of 1.83 which was estimated in the previous researches (Kaplan and Rich, 2017). Moreover, it is also different to the result in Valero (2016). Hence, the Miller's version of Pythagorean formula is given as follows:

$$\widehat{WCPT}_{Miller} \equiv \frac{\left(S/_{GP}\right)^{1.766423}}{\left(S/_{GP}\right)^{1.766423} + \left(A/_{GP}\right)^{1.766423}}. \tag{21}$$

3.3.2 Generalized Pythagorean formula

As mentioned above, the following double-log regression model can be used to find the estimates of the parameters:

$$\ln(Odds) = \ln(K) + \beta_1 \cdot \ln(RS) + \beta_2 \cdot \ln(RA) + \epsilon, \tag{22}$$

where, *Odds* stands for the odds ratio which is defined as the ratio of wins and losses. And ϵ is the random error. The following table shows the regression results.

Table 6
The estimating results for the generalized Pythagorean formula

Variable	*LnOdds*
ln(RS)	1.7773***
	(34.13)
ln(RA)	-1.7585***
	(-38.22)
ln(K)	-0.03
	(-0.32)
Obs.	300
Pseudo	0.8850

Note: The value in parentheses is the t-value of the parameter estimate. *, ** and *** are represented the significant level of 10%, 5% and 1%, respectively.

According to Table 6, it can be found that the estimates of ln(*RS*) and ln(*RA*) are different. As the test statistic for testing the null hypothesis: $\beta_1 = -\beta_2$ is 2.15 with *p*-value 0.04, then the hypothesis is rejected. In other words, the exponents of *RS* and *RA* in the Pythagorean formula for baseball are significantly different. This result is contradict to all versions of Pythagorean formula for baseball.

4. Models Assessment

In this section, there are two assessment methods can be used, i.e., mean squared errors (MSE) and mean absolute errors (MAE). The MSE and MAE are defined as

$$\text{MSE} \equiv \frac{1}{N}\sum_{i=1}^{N}\left(\widehat{\text{WinRatio}}_i - \text{WinRatio}_i\right)^2, \tag{23}$$

and

$$\text{MAE} \equiv \frac{1}{N}\sum_{i=1}^{N}\left|\widehat{\text{WinRatio}}_i - \text{WinRatio}_i\right|, \tag{24}$$

respectively. In which, the $\widehat{\text{WinRatio}}$ is the estimated WinRatio.

Moreover, according to Chen and Li (2016), the accuracy rate of a model is defined as

$$\text{Accuracy}(\lambda) \equiv 100 \times \frac{1}{N}\sum_{i=1}^{N} I_{\left\{\frac{\left|\widehat{\text{WinRatio}}_i - \text{WinRatio}_i\right|}{\text{WinRatio}_i} \le \lambda\right\}}, \tag{25}$$

where, I_A is an indicator function that gives value of 1 if $x \in A$ and 0 otherwise. In addition, λ is a threshold value, in this study, the values of λ are given three threshold values of 3%, 8%, and 10%, respectively.

4.1 Overall assessment of models

Therefore, the MSE, MAE and Accuracy of in-sample prediction and out-of-sample forecasting are shown in the following table.

Table 7

MSE and MAE for the in-sample prediction and out-of-sample forecasting

	OLS	2-Stage	Poisson	James	Miller	Smyth	Generalized
Panel A: In-sample prediction							
MSE	0.0025	0.0031	0.0195	0.0034	0.0032	0.0032	0.0032
MAE	0.0372	0.0415	0.0962	0.0449	0.0433	0.0433	0.0433
Accuracy (3%)	51.67	47.67	19.67	44.67	44.67	45.00	44.33
Accuracy (8%)	89.33	87.67	56.00	85.33	86.67	86.67	86.67
Accuracy (10%)	95.67	92.67	66.67	90.33	92.67	91.67	92.67
Panel B: Out-of-sample forecasting							
MSE	0.0027	0.0027	0.0085	0.0039	0.0033	0.0034	0.0033
MAE	0.0416	0.0424	0.0703	0.0512	0.0449	0.0469	0.0450
Accuracy (3%)	46.67	46.67	36.67	36.67	33.33	36.67	33.33
Accuracy (8%)	86.67	86.67	56.67	80.00	86.67	86.67	86.67
Accuracy (10%)	96.67	96.67	73.33	90.00	90.00	90.00	90.00

As shown in Panel A of Table 7, the MSE and MAE using OLS is the lowest than that of other models. Indeed, since the accuracy rate of the multivariate regression model is as high as 95.67%, it is the highest among all models, however, the accuracy rate of the generalized Pythagorean formula is 92.67% which is the highest among all version of the Pythagorean formula. Therefore, as for the assessment of in-sample prediction, the OLS and generalized Pythagorean formula are the best model in their individual class, respectively.

On the other hand, in Panel B, the MSE, MAE and accuracy rate of the

Pythagorean formula are as good as that of the regression models, except the James' version of Pythagorean formula. Furthermore, the MSE and MAE of the generalized Pythagorean formula proposed in this study are lower than that of other versions of Pythagorean formula. Hence, the generalized Pythagorean formula is a better model in forecasting the winning ratio of the MLB team.

4.2 Prediction accuracy by leagues

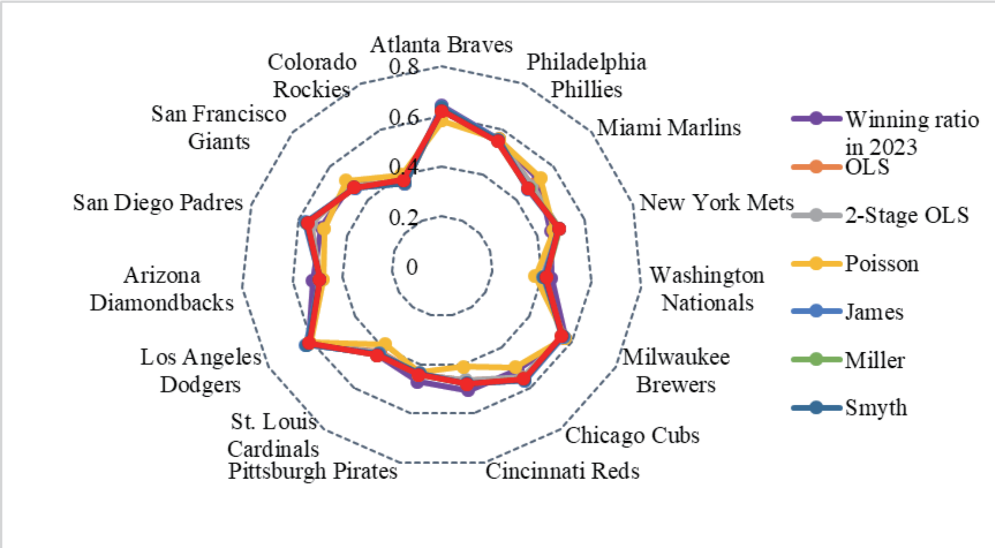
Totally, MLB has a total of 30 teams and is evenly divided into two leagues: the American League and the National League. Each league is divided into three divisions: East, West and Central. Therefore, each division has 5 teams.

4.2.1 Prediction accuracy for National League

There are 15 teams in the National League. The team with the highest rank in each division of the Eastern, Western and Central divisions will qualify for the playoffs. In addition, the other 12 teams will be ranked according to their records, and the top three will qualify for the wild card. Based on the aforementioned models, this study estimates the 2022-2023 winning ratio for each team. Estimating results are shown in the following diagram. The true winning ratio of 16 American League teams is in purple; forecasting results from OLS, 2-Stage OLS and Poison regression are in orange, grey and yellow, respective. Forecasting results by James' version, Miller's version, Smyth's version and generalized version of Pythagorean formula are in light blue, green, deep blue and red, respectively.

Figure 3

The estimates of winning ratios for teams in National League



The results in Figure 3 show that, beside the Poisson regression model, both the OLS and 2-Stage regression models can correctly estimate the winning ratio of the eight National League teams entering the 2022-23 playoffs. However, each version of the Pythagorean formula underestimates the winning ratios of these eight teams. Moreover, when it comes to estimating the winning ratios of the top two teams in each division of the National League, the generalized Pythagorean formula has good estimation results. Furthermore, the assessment results are shown in the table below.

Table 8

Forecasting winning ratio of 2023 regular games: National League

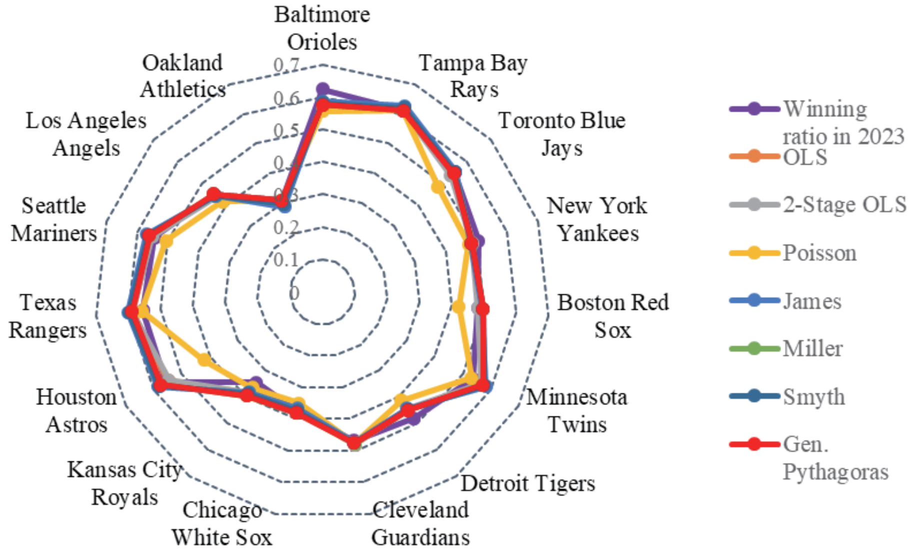
Assessment	OLS	2-Stage OLS	Poisson	James	Miller	Smyth	Generalized Pythagoras
MSE	0.0030	0.0029	0.0074	0.0043	0.0035	0.0038	0.0035
MAE	0.0446	0.0453	0.0660	0.0525	0.0497	0.0495	0.0500
Accuracy (3%)	40.00	40.00	40.00	40.00	26.67	40.00	26.67
Accuracy (8%)	80.00	86.67	53.33	80.00	80.00	80.00	80.00
Accuracy (10%)	100.00	100.00	80.00	86.67	86.67	86.67	86.67

In Table 8, except for the Poisson regression model, the estimation results of the two regression models are better than those of each version of the Pythagorean formulae. Moreover, in terms of accuracy, even though the threshold is released, the Pythagorean formulae is lower than those of the regression models. However, the generalized Pythagorean formula for baseball proposed in this study has more theoretical significance since it is derived from a Cobb-Douglas production function.

4.2.2 Prediction accuracy for American League

Next, this study also uses the aforementioned models to forecast the winning ratio of the 15 American League teams in the 2022-23 season. The team with the highest rank in each division of the Eastern, Western and Central divisions will qualify for the playoffs. In addition, the other 12 teams will be ranked according to their records, and the top three will qualify for the wild card. Such that, the estimating results are shown in the figure below.

Figure 4



The estimates of winning ratios for teams in American League.

As shown in the Figure 4, the eight teams that entered the 2022-2023 playoffs, except for the underrated Toronto Blue Jays and the overrated Seattle Mariners, seven were correctly predicted to qualify. In addition, with the exception of the Tampa Bay Rays, the no other team's record predictions in the American League is higher than the Texas Rangers. Furthermore, the assessment results are shown in the table below.

Table 9

Forecasting winning ratio of 2023 regular games: American League

Assessment	OLS	2-Stage OLS	Poisson	James	Miller	Smyth	Generalized Pythagoras
MSE	0.0024	0.0025	0.0096	0.0034	0.0030	0.0030	0.0030
MAE	0.0387	0.0394	0.0745	0.0499	0.0401	0.0442	0.0401
Accuracy (3%)	53.33	53.33	33.33	33.33	40.00	33.33	40.00
Accuracy (8%)	93.33	86.67	60.00	80.00	93.33	93.33	93.33
Accuracy (10%)	93.33	93.33	66.67	93.33	93.33	93.33	93.33

In Table 9, except for the Poisson regression model, the estimation results of the two regression models are better than those of each version of the Pythagorean formulae. However, in terms of accuracy, when the threshold is released, the Pythagorean formulae is consistent with both the regression models. Therefore, the generalized Pythagorean formula proposed in this study has more theoretical significance since the performance of the generalized Pythagorean formula for baseball can also be improved by introducing other possible factors, such as superstar players, last season's record, main players changing teams or entering the disabled list, etc.

5. Discussion and Implications

5.1 Discussion

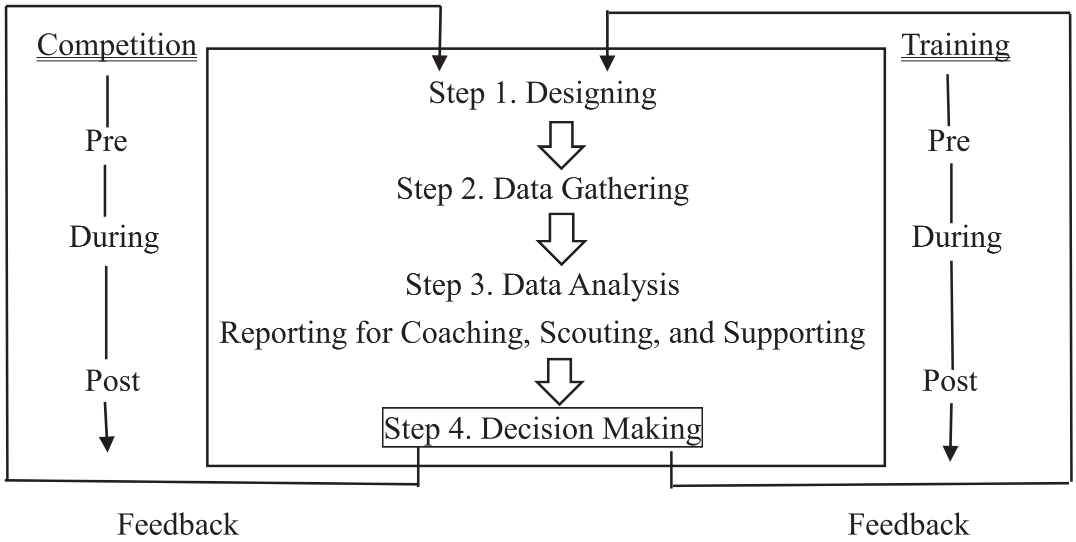
As the generalized Pythagorean formula proposed in this study has pointed out that the effects of offensive performance and defensive performance are not equivalent. This result is obviously different from various versions of the Pythagorean formula in the past. However, it has more economic significance and extensibility. For economic significance, through the Cobb-Douglas production function in macroeconomics, incur two main inputs: offense and defense, and then estimate the team's win-loss ratio (odds ratio), which is used as the team's entire season performance.

Furthermore, the extensibility is that the Cobb-Douglas production function is not limited to only two inputs, so other factors that may affect the output can be included, too. The factors are then brought into the function in order to be more consistent with the actual situation of the output model. For instance, the total salary of the players which represents the amount of investment the team has made in the players. It is hoped that the addition of players will bring positive effects to the team and improve the team's performance. Such that, the regression model in eq. (22) can then add the factor "the average of the total salaries of the players". Another factor that may affect the team's winning ratio is the fans, because their strong support will be one of the reasons for the players to win. Therefore, another variable that can be added to the model is the "average number of attendance".

5.2 Management implications

According to the empirical results of this study, the winning ratio of a professional team is significantly correlated to its overall offensive performance and overall defensive performance (Martin, 2016; Pavitt, 2011; Yoon and Choi, 2022). The overall offensive performance is significantly positively correlated to team's winning ratio, however, the overall defensive performance is negatively significantly. In competition or training in sports, the evaluation of a team's performance is generally completed by the coaches, agents and the public media, etc. (Park and Kang, 2014). According to the opinion in Park and Kang (2014), a process in evaluating sports performance is shown in the following figure.

Figure 5
Process for evaluating sports performance



In the above-mentioned sports performance evaluation process, a very important point is "Feedback" (Park and Kang, 2014). Whether it is the collection of training data or the analysis of competition results, it is necessary to use a feedback mechanism to allow the coaching team, training team and management to understand the team status and then to facilitate the activation of subsequent support systems (Martin, 2016).

5.2.1 Strategies for offense promotion

First, how does a baseball team create runs scored? Naturally, it is to compete with opponents, improve offensive performance, and create a niche. In the generalized Pythagorean formula, a professional baseball is concerned, finding/cultivating excellent hitters, and promoting players with high on-base rates, etc. These are ways to increase offensive performance. For instance, the Los Angeles Dodgers recruited Shohei Ohtani in 2023, focusing on his hitting performance, which can bring more offensive efficiency to the team. Therefore, the Dodgers arranged Ohtani in the first three at-bats to facilitate the start being able to attack opponents smoothly and did not allow Ohtani to step onto the mound as a pitcher.

5.2.2 Strategies for defense promotion

In addition, as for how a team reduce losses? For professional baseball teams, good defensive performance is to reduce the opponent's score. Therefore, to find/train pitchers with low (ERA), and to promote players with high blocking rates, etc., can be regarded as a means to improve defensive performance. For example, before the opening game of the 2022-23 season, the Twins and the Padres reached a deal, which will have a significant impact on the strength of the two teams. The transaction package is as follows: the Twins released the 31-year-old left-hand closer Taylor Rogers, the 27-year-old former hitter Brent Rooker was traded to the Padres for 26-year-old right-hander Chris Paddack and right-hander Emilio Pagán, who will turn 31 in May of that year.

Moreover, a good field commander can direct the pitcher's distribution of the ball to deal with the opponent's batters, and guide the defender's defensive zone adjustment to reduce the chance of missing the ball and increase the blocking rate. Such a commander is a catcher. To find a good catcher is also an important defense promotion strategy for the team. For example, on December 13, 2022, a three-party trade occurred in Major League Baseball. The Atlanta Braves, Oakland Athletics and Milwaukee Brewers completed a large-scale transaction involving 9 players. The Braves acquired 28-year-old catcher Sean Murphy, who is 2021 American League Gold Glove players, the Warriors spent a lot of money and sent out 7 players in one go.

5.2.3 Overall strategies

Overall, a sound coaching team is also one of the key factors in the team's success (Soebbing and Washington, 2011). Before the season, the coaching team formulates a training plan, uses spring training and warm-up games to adjust the players' physical and mental condition and order, and after the start of the season tactical changes. Before the game, the coaching team draws up a combat plan. Players on the field accept the instructions from the coaching team to implement tactics. Offensive tactics and defensive strategies must be balanced. Otherwise, they will lose sight of one and lose their footing. Therefore, hiring an excellent coaching team is also an improvement strategy for the overall strength of the team. For instance, in 2021, Atlanta Braves head coach Brian Snitker who has been consistent for forty-five years, dedicating his life to Braves. Until this year, he led Braves to play all the way to the World Championship. The Braves also defeated the Astros 7-0 in Game 6 of the World Series on November 3 of that season, winning the fourth Gold Cup.

Furthermore, managers are also a very important part in team management (Schyvinck, Babiak, Constandt, and Willem, 2021). In addition to hiring an excellent coaching team, recruiting players, and mediating disputes, managers must also organize a medical team to take care of the players so that they can maintain their best condition and compete. Moreover, due to the emphasis on fans, managers must work harder to manage consumer loyalty to the team, build the team's brand value (Lee, Bang, and Shonk, 2020), and promote players to participate in social responsibility activities to enhance their personal value (Inoue, Kent, & Lee, 2011; Walzel, Robertson, and Anagnostopoulos, 2018). Therefore, good managers can be one of the factors that improves the overall performance of the team.

6. Conclusions

6.1 Limitations

The purpose of this study is to investigate the winning ratio of Major League Baseball teams by proposing the generalized Pythagorean formula. Therefore, the empirical research data of this study are the season results of the 30 Major League Baseball teams. However, for professional baseball in other regions, such as Chinese Professional Baseball League (CPBL), Korean Professional Baseball League (KBO), Japan Professional Baseball League (NPB), etc., it may not necessarily have the same results. Moreover, for the other professional sports, such as football, hockey, soccer, volleyball, tennis, golf, etc., due to the large difference in properties, the research method proposed in this study may not be applicable, and other models may need to be developed to study it.

6.2 Conclusions

This study proposes a generalized Pythagorean formula in estimating in estimating the winning ratio of MLB teams. By setting a Cobb-Douglas function for the win-loss ratio, the expected winning ratio can be derived by this generalized Pythagorean formula as like as the form of the Pythagorean formula which is first proposed by James (1980). Different to the original form, the generalized Pythagorean formula has different exponents for the factors, a constant to capture the impact of some non-quantitative factors. More important, the generalized Pythagorean formula is extensible by employing more factors that may have effects on the winning ratio.

Moreover, the empirical results show that that each version of Pythagorean formula has a higher accurate rate of predicting the expected winning ratio. The generalized Pythagorean formula does as well as all version of Pythagorean formulae do. In addition, the parameters in the generalized Pythagorean formula can be estimated by using a double log-linear regression model. Such that, it is testable by the historical data.

Furthermore, based on the definition of the Cobb-Douglas function, many other factors that may affect the win-loss ratio can be added to the model, such as ERA, *AVG*, or other factors. And since stochastic efficiency analysis is also based on

Cobb-Douglas function. Therefore, team managers can use the results of this study to explore the team's efficiency performance during the season (Lee, 2011). Moreover, as indicated in Gordon (2020), this method can be used as a reference for team formation in the coming year, such as selecting potential players through the draft, recruiting new players who are low ERA pitchers, high run-batted-in (RBI) hitters or high blocking rate fielders, or player trades to improve the team's performance.

6.3 Future research directions

Future research directions can be divided into two aspects: First, methodological improvements. By introducing artificial intelligence and machine learning, we can find data-driven models and further extend them to the study of winning ratios in other professional sports. The second is practical applications. Based on the results of this study, some data mining methods can be used to find players who are actually in line with the team's plan and recruit them to further achieve the team's goals.

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運用廣義畢氏公式估計美國職棒大聯盟球隊的勝率

蕭秋銘
國立雲林科技大學財務金融系

摘要

本文欲藉由廣義畢氏公式法來估計美國職棒大聯盟常規賽的勝率。經由過去 10 年賽季 30 支美國職棒大聯盟球隊的攻守紀錄，本文驗證了廣義畢氏公式對於球隊的勝率具有極高的預測能力。實證研究的結果亦顯示，本文的多元迴歸模型相或是二階段迴歸對於 Poisson 迴歸模型都有較高的預估能力。而且不管是樣本內估計，還是樣本外預測的 MSE 與 MAE，本文所提出的廣義畢氏公式對於勝率的估計都不比其他版本的畢氏公式差。然而，由於本文的廣義畢氏公式是經由 Cobb-Douglas 產出函數推導而得，因此不僅具備經濟意涵，可以透過計量模型檢驗之，而且此模型更具有彈性 (flexibility) 與擴充性 (extensibility) 。再者，球團管理階層亦可透過此公式招募所需的球員，以便提升戰力，提高勝率。

關鍵詞：棒球畢氏公式、Cobb-Douglas 產出函數、勝敗比

由《申報》看遠東運動會報導－女性運動員參與提升及社會形象之轉變

邱盈蓁
國立中正大學中國文學系暨研究所

摘要

現今社會生活模式與媒體資訊緊密結合，報紙產物出現至今，成為人們生活傳遞訊息的方式之一。在中國，《申報》是近代發行時間相對長久，且為發行量大之刊物，對於研究者欲瞭解當時社會事件面貌，提供豐富史料價值，本篇研究採文獻分析，依《申報》報導中遠東運動會相關新聞內容，透過報導觀察女性運動項目發展狀態。《申報》發行恰與遠東運動會舉辦時間重疊，亦是《申報》發行歷時中表現最活躍的運動賽事。一場運動會舉行經常伴隨有形與無形的價值，並賦予精神象徵、社會意義。於此同時，筆者透過觀察《申報》報導該賽會內容過程時，發現女性運動員在遠運會參與人數逐次增加，循此探討運動員性別投入變化原因，並透過該報呈現其相關內容，從而瞭解媒體及大眾看待女性運動員參與轉變，有助於重視性別平等的現今社會，提供新聞媒體者在報導過程中，如何運用不同的形式、手法，以達到賽會新聞宣傳目的及預期效益。

關鍵詞：申報、遠東運動會、女性運動

通訊作者：邱盈蓁
E-mail：fallday.tw@yahoo.com.tw
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壹、前言

近代人類生活型態與媒體息息相關，報紙在 15 世紀時期發明於歐洲，後傳至東方國家，在人類社會與生活中具有傳遞訊息的功能。中國近期曾發行《申報》此刊物，其為使用中文字的商業日報，在 1872 年由英籍茶商美查（Ernest Major）創辦成立，原稱《申江新報》，至 1949 年停刊後縮寫成《申報》，前後出版歷時共七十八年。新聞報導必備的首要條件：第一，報導內容要與時俱進且保持即時性。第二，須具備事件真實性。因此，在種種不易條件限制下，《申報》仍是中國近代發行時間僅次《中央日報》的報刊，對於研究學者瞭解當時社會事件，提供豐富史料價值，故知其在中國社會中有鉅大的影響，並揭示予大眾諸多社會面相。另，《申報》中刊載許多運動相關篇幅報導如：運動賽事、運動相關招生、運動產品廣告等等，對欲研究中國在此階段運動發展內容者，提供豐富、多元的運動史料。

國家人力發展健全與否影響運動風氣強盛或衰弱，人民為國家的重要資源，因而如何培養良好的體魄，進而打造健康運動生活樣貌，是極需國家政策支持，並長期投入經營。追求運動強身健國過程，須探討運動員性別投入程度差異，造成社會現象改變，有助新聞媒體者在報導形成中，對性別如何在運動賽會呈現有所幫助，並達成報導預期效益。本篇研究參考《申報》報導內文，以其發行的時空背景，與遠東運動會舉行時間重疊，且為該報刊中篇幅最大之體育賽事，業已分析該運動賽會中，備受關注之女性運動相關資訊，提供現今媒體在報導過程中參考之方向。

筆者透過查找中正大學圖書館藏《申報》複印資料進行觀察，以遠東運動會報導下觀察女性運動員表現狀況，帶出該相關報導所見，並提出如何影響社會大眾。《論語》：「君子無所爭，必也射乎」，運動會的舉行除了享受競賽成果之餘，背後賦予的精神意涵、社會價值更值得重視，運動賽會現場能帶來人潮前往，而除了一般到場觀眾之外，期間為了讓未能到運動場上，卻也關注運動賽事者便利獲取活動各項訊息，因而，使得記者們前往運動場上記錄報導，游鑑明（2012）對於《申報》中報導遠東運動會的記者角色描寫：「每當有運動比賽時，他們就蜂擁而至，把競賽過程、比賽結果，乃至觀看的心得，一一

刊載在報刊上。對無法到現場觀看運動比賽的民眾來說，報紙是提供體育消息的重要管道，特別是在區域、全國性或遠東運動會舉辦的時刻，人們只要打開早報或晚報，運動會的活動情景便盡收眼底。」（頁 145）

報紙於現今生活已是唾手可得，無論早期發行的紙本形式，又或文明社會因資訊進步下而有電子報的流行，報紙儼然成為人類傳遞訊息的重要方式之一，近代雖有多家報社創刊，然而《申報》卻能自清末到民國初年長達七十八年的發行，可知其在當時中國社會下受到大眾的支持，經歷漫長的時光與生活環境變化，讀者由初時看待《申報》報導樣貌，再比較時間推移後的報導內容，發現媒體工作者在呈現事件的風格、力度、觀點等，皆有所差異。如關於遠東運動會報導，由一開始僅數則且文字精簡的版面，再到後來有專屬遠東運動會的特刊數頁，可見遠東運動會受到社會大眾逐漸重視，更影響媒體工作者報紙版面的製作模式。

藉由閱讀《申報》報導內容，窺知日益增加的運動相關新聞，透過這些出刊文字訊息瀏覽，為讀者注入新知識，其中包含女性運動的推行，報導中介紹中國彼時女性運動下社會投入面貌，這類新聞帶給大眾在運動思潮上新衝擊、新視野，更對中國女性運動普及推波助瀾。在 2017 年臺灣發布《推廣女性參與體育運動白皮書》，是女性運動推展重要政策宣言，以「健康女性、運動培力、友善環境」為願景，以提高女性規律運動人口，促成臺灣社會中的運動性別平權。因而在國家推動下，藉由瞭解歷史上運動賽會中女性運動發展演變，對現今政策推行有其助力與意義。

貳、研究方法

受西方傳教士的推廣，報紙成為社會傳播新聞的管道，本文探討的運動活動由此達到宣傳推行的效果，如《申報》（1872 年 4 月 30 日）創刊號的第一條新聞，恰巧標題「馳馬角勝」即是運動新聞，報中內容記載了當時西方賽馬的景象：「西人於二十二日至二十四日，連日馳馬角勝負，定於十二鐘馳三次，停一點鐘，稍微休息再馳至夜方散 · 當其馳之際，西人則異樣結束，務求精彩，或二三騎或三四騎連轡而行，風馳電疾、石走沙飛，各向前驅不為後殿，倘行

走整齊無有參差，則勝負均焉，若一騎稍有先後，則高下立判，勝者楊楊(洋洋)自得，負者退然氣沮，而旁觀則私相賭賽，以馬之優絀判我之輸贏。...... 西人成往觀焉，為之罷市數日，至於遊人來往士女如雲則大有溱洧間風景，或籃輿笥轎得得遠來，或油壁小車轔轔乍過，或徒倚於樓上，或隱約於簾中，莫不注目凝神，觀茲奇景。而蹀躞街頭者，上自士夫，下及負販，男女雜遝，踵肩摩，更不知其凡幾矣」。

文中將賽馬的競賽規則、賽事場景、比賽結果，甚至提及觀賞賽馬的民眾為了前往參與而停止數日的工作，並寫出關注賽馬活動者並非僅男子，婦女們也醉心其中，無論是社會地位階層高的人士或勞動者，紛紛競相投入賽馬活動。《申報》是中國近現代體育的見證者與記錄者，為中國近現代體育事業的發展起到了重要的推動作用，做出了重要貢獻（文媛，2013）。透過記者筆下將西方賽馬活動真實呈現，在文字詞彙描述得宜中，使得讀者深刻感受賽馬盛事，並看見其活動受到西方普羅大眾的重視，除此更將比賽實況細膩生動寫出，經由這些概況報導，讓讀者瞭解與參與西方賽馬文化。

《申報》不僅是歷時久遠的報紙，筆者發現在其多篇運動相關報導中，特以遠東運動會的一系列報導對後來中國運動發展有深遠的影響，亦為中國歷史上最早的運動會報導，並具歷史上重要轉捩時刻。遠東運動會是亞洲地區最早的地區性運動會，肖鴻波（2011）對《申報》在遠東運動會報導研究提出：「《申報》對遠東運動會報導於大眾的啟示，二十年對於歷史長河來說不過是短暫的一瞬，而對於中國體育的新聞報導來說，卻是關鍵一刻，在這一刻裡中國的競技體育慢慢走向成熟，在這一刻裡，中國報紙對於體育的報導理念也慢慢成熟。運動會的發展和體育觀念的成熟，完全有賴於與新聞媒體的不間斷的傳播。」因此，《申報》中遠東運動會的報導對於中國的體育報導、運動會報導，給後世運動會報導帶來了許多啟示性的意義。除了報中對運動的推廣之外，學者認為《申報》中呈現女性形象與傳統相較有所轉變，對此也提及：「很多的年少女子甚至已婚的婦女開始效仿廣告中的知識女性，她們追逐流行，崇尚休閒，享受生活，開始擺脫傳統社會的角色，並向都市女性的角色轉化，讀書及體育運動漸成時尚」（李文瑾、都凌霄，2010），在當時社會下女性對運動接納程

度於報中有了明確的說明。

遠東運動會促使中國體壇走上國際舞台，同時受到大眾高度關注，第十屆遠運《申報》（1934 年 5 月 10 日）標題：「遠運會明日開幕，我國選手勤練不輟。...... 會場已成熱象，入場券已預定將完」，遠運會受到大眾極大重視，賽會運動員性別成員除男子外，女性運動員亦在此時脫穎而出，報導內容除了男子運動項目外，女性運動表現逐漸展露，本文透過《申報》遠東運動會相關報導，瞭解近代中國女性運動發展樣貌，觀察彼時媒體工作者實際的報導模式，如何成功吸引社會大眾對運動賽事的關注。

現今運動成為大眾日常與整體社會普遍流行的活動，然而在賽會場上女性運動選手比例相較男性少，另在國人男女運動時間投入，其生活上所佔時數比例，女性亦較男性低，於此，性別平權議題值得時人留意與重視。《申報》對運動傳播特點有三：一為內容豐富、報導全面，二為聚焦賽事、不吝篇幅，三為形式多樣、不一格（文媛，2013）。對於中國運動傳播推廣的發展能切實推行與提倡，且於當社會女性運動發展未能普及時，能表明自己的態度和立場，如其曾連續刊載發行暨南大學體育部主任陳掌愕的文章——《中國女子體育》，便是極力鼓吹提倡女性運動。本文欲透過《申報》觀察報中首次寫入運動會報導－遠東運動會，藉由中國運動會開始出現女性運動員在報上，進而瞭解女性運動員形象之轉變，以提升女性國人對運動的投入。

參、遠東運動會下社會發展概況

「遠東運動會是基督教青年會主導之一國際運動會」（徐元民，2005），其發展的意義在「使東方的民族互相攜手，藉體育運動而敦和睦，增進彼此的交誼」（阮蔚村，1933，頁 1），首次運動會是由菲律賓發起，聯合中國和日本於 1912 年成立，自 1913 年到 1934 年共舉辦了十屆，舉辦地點、人數整理如表 1。

表 1

中、日、菲參加歷屆遠東運動會人數統計表

	城市	年代	中國	日本	菲律賓	合計
第一屆	馬尼拉	1913	40	20	70	130
第二屆	上海	1915	100	20	90	210
第三屆	東京	1917	50	144	70	264
第四屆	馬尼拉	1919	100	60	130	290
第五屆	上海	1921	140	70	130	349
第六屆	大阪	1923	113	177	146	431
第七屆	馬尼拉	1925	125	142	174	441
第八屆	上海	1927	180	160	170	510
第九屆	東京	1930	170	180	175	525
第十屆	馬尼拉	1934	150	120	180	450

資料來源：阮蔚村（1933）。遠東運動會歷史與成績。上海：勤奮書局。

每兩年舉辦一次遠東運動會，由中、日、菲三國輪流主辦，其中有三屆是在中國上海舉行，參加遠運會人數隨時間逐漸增多，到最後一屆，因日本欲將偽滿州國加入會員國，遭到中國代表的反對，維持二十二年遠東運動協會遂告瓦解。

「中國今日一切的體育設施，和一切的體育指導人才，無非均是受遠東運動會，直接和間接的影響而促成和造就。」（阮蔚村，1933，頁 2），遠運會含括比賽項目分為：田徑 (含田賽：一百碼、兩百二十碼 ...... 到五英哩賽等，以及接力賽。徑賽可分為：擲鐵餅、推鉛球、跳高、跳遠、撐竿跳)、全能運動會、游泳 (含仰泳、俯泳)、足球、棒球、籃球、排球、網球 (含單打、雙打)，共八大項。

西方國家投入體育活動較早起步，相較對於投入比賽活動較晚的東方國家，觀照《申報》報導中國遠東運動會早期及後期比較分析後，發現媒體報導下所表現的面向，前後階段時期差異甚大，後期已不同既往的報導模式。

一、遠東運動會中國女性成員參與分析

遠運後的運動選手性別成員可見改變，優異的中國女性運動員除了參與國內運動會，並在國際運動會中逐步顯露身影，亞洲地區重要的遠東運動會在「第五屆遠運會中，中國女學生以團體體操表演，首次在運動會中露面。」（游鑑

明，2012，頁 142），前四屆未有任何婦女參與國際運動活動，後來開始有婦女走上國際運動舞台表演，第六屆參加遠運會中國人數為一百零三人，包括女子網球兩人，以及女子排球華南代表隊。「在一九二三年，大會為倡導女子體育，加入女子排球和女子網球的比賽，此後的遠運會都有中、日、菲三國女運動員的身影，只不過到這個時期她們出席的是表演項目。」（游鑑明，2012，頁 143），女性運動舉辦至這個時期，尚處於萌芽階段未尚有成績展現。

而後，女性運動員人數逐漸增加，第七屆遠運會中女子排球選手有十五人，女子網球有一人，第八屆「因華東地區有能力組織排球女隊的學校僅有拜禪文、民立和中西三所女校，這一年，華東地區的十六名球員代表，即選自禪文和民立。」（游鑑明，2012，頁143）。再到第九屆增加女子游泳項目選手兩名。此時，女運動選手已在遠運上開始展露佳績，於此同時，引起國人廣泛關注。「第七屆的女排比賽中，以二比零擊敗日本隊；第九屆的女網賽中，榮獲冠軍；然而最讓中國驕傲的是，楊琇瓊在第十屆女子游泳比賽中的傑出表現，她個人獨攬了各項泳賽表演的冠軍。」（游鑑明，2012，頁 149），《申報》（1934 年 4 月 19 日）於一九三四年遠運結束時，其中對女子游泳項目報導：「女子游泳，我國美人魚楊琇瓊，此次在菲風頭大健，包辦各項游泳冠軍，游泳場中，我國國旗屢升，國歌迭奏，觀者掌聲不絕，為我國在遠運會中空前未有，大爭國家體面，菲人譽之為「中國小姐」云」，女性運動員表現到此階段可說進入蓬勃發展，中國運動表現受到國際肯定，走向大放異彩，並激起人民民族意識，受到中國社會大眾熱烈推崇與讚揚。這些中國女性運動選手，以運動競技的方式讓中國在國際體壇上揚眉吐氣。

二、社會看待女性運動員的審美觀

（一）病弱美走向健美

在中國傳統社會下，女性被期待成為賢妻良母，婦女外在穿著上固有一套制式審美標準，特別是對婦女形體約束，如女性「裹小腳」這類不合宜於現代，卻是當時社會普遍的期許，此風俗一直到清末始廢纏足，逐漸鬆綁對女性身體傳統束縛，及對她們身體框架的解放，同時女性轉而關注鍛鍊體魄與運動技能，這類對身體美感上的轉變，由傳統普世認知的病弱美轉而追求體態的健

美。因此，學者提出「《申報》中女性廣告文化作為現代廣告的典型代表，不僅是報業史上探索媒介經營的先驅和範本，也參與了當時上海都會文化和城市氣質的構建，體現了當時現代性轉型中的上海大眾的日常審美意識」（張晨陽，2005），而在思想形式上，婦女萌生追求自我實現，而她們的活動場域也從室內與家庭中走出至戶外。女性運動活動的流行為婦女帶來新思潮及新審美觀。

女性運動員外在的改變，除了身材形態、穿著打扮之外，包括髮型也有所差異，女性運動員的髮型款式亦成為大眾關注的焦點，游鑑明以一九二七年的遠東運動會為例，「當時代表中華隊參賽的華東女排球球員，全體梳著短髮出場比賽，與束著髮辮的對手 — 日本女選手，形成強烈對比，在短髮剛流行的時代，華東隊的髮型確實”絕驚四座”。」（游鑑明，2012，頁 156），伴隨著時代背景的不同，大眾看待女性運動員審美觀逐漸改變。

《申報》（1934 年 5 月 10 日）一則電影廣告《體育皇后》：「打倒病態美的捧心西子！養成健康美的模範女性！」社會從對女性美的觀感由體態柔弱美，轉而提倡健康形象美。遠東運動會時期，中國體壇紛紛出現諸多優秀女性運動員，她們的外表與過往傳統纖弱形象迴異，以健美線條的外型展現於大眾，如泳將楊琇瓊被大眾視為「標準美人」（申報，1933 年 11 月 30 日），「她們身著運動衣，健康美麗的形象，屢現報端，很大程度上改變了公眾的傳統審美，社會對於女性健康美、運動美逐漸產生認同。」（張文慧、郭勁宇，2013，頁 301），透過《申報》遠東運動會系列報導，觀察當時社會上看待女性外在審美的變化，除了女性社會地位提升，同時相較過往傳統婦女穿著不宜裸露，以及女性須為家庭主內等，婦女在社會期待下的樣貌演變發展至此，無論內、外在形象皆重新被賦予新面貌。

（二）女性運動之美展現

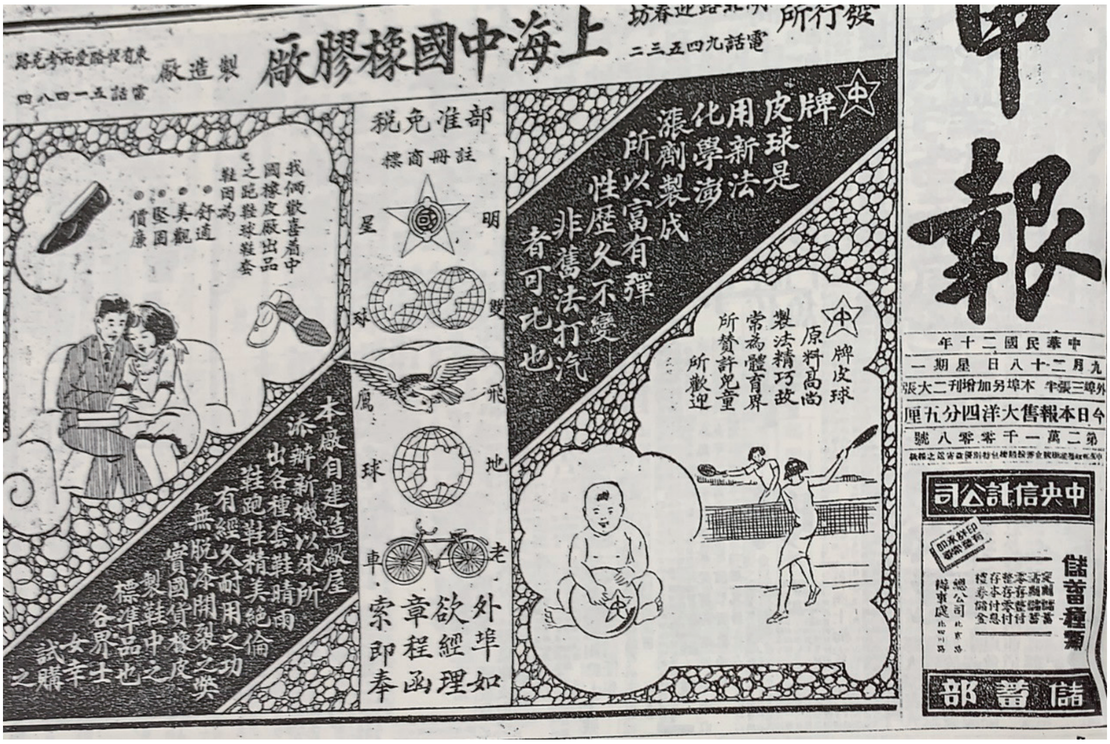
報紙內容上除了文字敘述外，還可在報紙圖像上來傳達到預期目的，透過圖像展現不同畫面意涵及傳達特定意識，然而這些圖像如何吸引讀者？在一九三四年五月十日《申報》的國貨特刊，有兩則與運動用品相關廣告，一則為一雙鞋排球鞋，另一則為永字皮球，如永字皮球廣告寫著：「永和兒童聯歡，活潑小朋友見了它，個個都樂得手舞足蹈。」（圖一）（申報，1934 年 5 月 10

日），此篇廣告除了文字，並搭配五名小孩手持皮球歡欣的樣貌，營造兒童玩球歡樂、健康的氛圍感。還有一九三一年九月二十八日《申報》上海中國橡膠廠的廣告圖片，圖中有一對恩愛男女，文字說明：「我倆喜歡中國橡膠皮廠出品之跑鞋、球鞋、套鞋是因為，舒適、美觀、堅固、廉價」，以及兩個正在打網球的女孩、一個正在玩皮球的小朋友」（圖二）（申報，1931 年 9 月 28 日），此廣告圖像展現女性運動健康姿態，表現出運動中的婦女給予正面、良好的感受，穿上體育服、鞋的婦女，流露愉快的模樣。報中廣告透過文字敘述，再加上廣告圖片，傳達女性運動時滿足、身心舒適健康的氛圍感。

圖 1

資料來源：申報，1934 年 5 月 10 日。

圖 2



資料來源：申報，1931 年 9 月 28 日。

肆、結語

遠動運動會影響中國投入體育活動甚鉅，透過報刊相關報導，開啟大眾廣漠視野，近代女性運動員的興起，除了在體壇掀起一股旋風，也為社會帶來運動員在性別觀念衝擊，透過報紙報導女性運動員，促使大眾關注她們，並從中探討與思考社會大眾審美轉變議題等。藉由《申報》文字及廣告等手法，觀察遠東運動會中女性運動員的社會形象改變，從而發覺社會大眾對於運動性別認知差異轉變，並分析媒體如何報導呈現，致使讀者能用新視角去看待女性運動員，及如何詮釋女性在運動場上的姿態與地位，對於當前講求性別平等的社會，及優秀女性運動員活躍的體壇中，提供現今媒體報導參考之方向，期盼未來新聞媒體對於運動相關報導，能帶給讀者以宏觀角度瞭解更多社會真實面貌。

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Shen Bao's Reports from the Far East Games: Enhancement of Female Athlete Participation and Social Image Transformation

Chiu Yin-Chen
Department of Chinese Literature, National Chung Cheng University

Abstract

In contemporary society, lifestyle and media information are intricately linked, with newspapers emerging as one of the primary mediums for disseminating information. In China, "Shen Bao" has a long-standing history of publication and is widely circulated, offering valuable historical insights for researchers seeking to understand the societal events of the time. This study employs a literature analysis approach, examining the relevant news content of the Far East Games as reported in "Shen Bao," to observe the development status of women's sports. The timing of the Far East Games coincides with the publication of "Shen Bao," making it one of the most prominent sporting events covered by the newspaper. Sporting events often carry tangible or intangible values and are imbued with symbolic and social significance. Concurrently, through an examination of "Shen Bao's" coverage of the event, it was noted that the participation of female athletes has progressively increased. This study delves into the reasons for changes in gender participation among athletes and presents pertinent factors through the newspaper, thus aiding in the understanding of the evolving perceptions of female athlete participation in media and public spheres. This contributes to contemporary society's emphasis on gender equality, providing insights for news media on how to effectively utilize different formats and techniques in their reporting to achieve the desired publicity and benefits of sports events.

Keywords: Shen Bao, Far East Games, women's sports

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