Research Article

Integrating Sports Risk Screening, Constitution-Differentiated Health Preservation, and Wearable Biosensing in Proactive Community Healthcare

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***Abstract*:** The paradigm shift from reactive clinical intervention to proactive community health management necessitates an integrative framework capable of synthesizing physiological monitoring, individualized preventive regimens, and physical activity safety. This study explores the architectural and operational convergence of wearable biosensing technologies, pre-participation sports risk screening, and Traditional Chinese Medicine (TCM) constitution-differentiated health preservation within community healthcare ecosystems. Rather than treating biomedical telemetry and traditional holistic diagnostics as mutually exclusive domains, we examine how continuous multi-sensor data streams can contextualize constitutional susceptibility and mitigate exertion-related adverse events across diverse demographic cohorts. Through a multi-phase exploratory synthesis involving community health centers, algorithmic signal processing evaluations, and longitudinal observational tracking, our findings suggest that coupling real-time physiological thresholds with personalized dietary and external therapeutic protocols may enhance early risk stratification and adherence to preventive care. Nevertheless, challenges regarding cross-modal data standardization, sensor thermal safety, and cultural-epistemological alignment between quantitative biomarkers and qualitative syndrome differentiation persist, indicating that further longitudinal validation is needed before widespread clinical standardization can be achieved.

Keywords:*Proactive Community Healthcare, Wearable Biosensing, Sports Risk Screening, Constitution-Differentiated Health Preservation, Multi-Modal Health Integration.*

1. Introduction

Modern community healthcare systems are increasingly burdened by the chronic sequelae of sedentary lifestyles, demographic aging, and fragmented preventive care, prompting a structural reorientation toward continuous, community-anchored health maintenance. Historically, primary care delivery has operated on an episodic, symptom-driven model that struggles to capture subtle physiological decompensations occurring between clinical visits. The proliferation of miniaturized wearable devices and edge-computing architectures offers a compelling avenue to bridge this observational gap, yet raw telemetry alone rarely translates into actionable behavioral modification without a coherent clinical and

cultural interpretive framework. In East Asian community health contexts, Traditional Chinese Medicine (TCM) health preservation (Yangsheng) provides a deeply ingrained theoretical scaffolding for individualized prevention, though its traditional reliance on subjective practitioner assessment often limits scalability and quantitative reproducibility.

Recent scholarship has begun to interrogate how digital infrastructure can formalize and extend these traditional paradigms. For instance, Yao [2] demonstrated the feasibility of embedding TCM health preservation standards within smart wellness digital systems, although their architectural framework primarily emphasized administrative standardization rather than dynamic, real-time physiological feedback loops. Similarly, while Chen [10] established a foundational standard system for traditional external therapies in health preservation, the operationalization of such standards within heterogeneous community populations remains somewhat constrained by practitioner-dependent diagnostic variability. To address these limitations, integrating objective biomechanical and electrophysiological screening becomes essential, particularly as community health initiatives increasingly prescribe physical exercise as a primary preventive modality.

The introduction of structured physical training into general community populations carries inherent physiological risks that are frequently underestimated in non-clinical settings. Pan [6] highlighted this vulnerability through the construction of a risk-screening system tailored for urban adolescent physical fitness training, revealing how standardized pre-participation evaluations can uncover latent cardiovascular and musculoskeletal susceptibilities; however, extending such screening protocols to multi-generational community cohorts requires accounting for vastly different baseline physiological reserves. Furthermore, as participation in high-intensity hybrid fitness modalities expands among urban adults, Minghao [13] analyzed the complex adaptation-related issues faced by diverse participating populations, underscoring the necessity of individualized load management to prevent overtraining and acute soft-tissue injury. Considering the above factors, a truly proactive community healthcare model cannot rely solely on periodic fitness assessments or static traditional classifications. Instead, it must weave continuous wearable biosensing into the fabric of both exercise risk mitigation and constitution-differentiated lifestyle intervention, while acknowledging that the epistemological friction between reductionist sensor metrics and holistic constitutional theories remains an open area of inquiry.

2. Methodological Architecture and Multi-Modal Integration Challenges

Designing a research methodology capable of bridging wearable biosensing, exercise risk stratification, and TCM constitution differentiation required navigating substantial technical, clinical, and operational complexities rather than following a linear engineering pipeline. Initially, our investigative team attempted to map raw photoplethysmography (PPG), accelerometry, and galvanic skin response streams directly onto established TCM constitutional categories, such as Qi-deficiency, Phlegm-dampness, and Yin-deficiency—using supervised classification models. During preliminary pilot testing across three community health service stations, however, this direct mapping approach proved overly brittle due to severe inter-individual baseline drift, motion artifacts during daily ambulation, and environmental temperature fluctuations. Consequently, we recalibrated our methodological architecture into a hierarchical, two-tier analytical framework that separates acute physiological safety monitoring from longitudinal constitutional profiling.

In the first tier, addressing hardware reliability and continuous signal acquisition, our sensor selection and power management protocols were informed by adjacent engineering breakthroughs in compact wearable

telemetry. Specifically, the thermal runaway early warning and safety management methodologies developed by Lin [1] for polymer lithium-ion batteries in wearable pet devices provided critical insights into localized thermal dissipation and battery stability under continuous skin-contact operation, which we adapted to ensure multi-day safety for elderly community participants wearing wrist- and chest-mounted biosensors. Moreover, when processing noisy acoustic and vibratory physiological signals, such as respiratory sounds and joint crepitus during movement screening—we drew methodological inspiration from Haipeng [4], whose work on acoustic recognition utilizing Mel-Frequency Cepstral Coefficients and lightweight neural networks demonstrated that high-accuracy feature extraction can be achieved on resource-constrained edge processors without continuous cloud offloading. To further resolve multi-channel sensor interference during dynamic physical exertion, the multi-sensor fusion control architecture proposed by Lin [5] offered a valuable reference for weighting accelerometer and physiological inputs, though adapting anti-interference thresholds from animal behavioral collars to human geriatric gait patterns required extensive empirical retuning and revealed unexpected sensor saturation during rapid postural transitions.

In the second tier, linking physiological telemetry to individualized therapeutic and preventive regimens demanded rigorous clinical categorization and historical-theoretical grounding. Rather than relying solely on self-reported constitutional questionnaires, which are prone to recall bias, we integrated structured meridian examination protocols and historical pharmacological data mining insights. The data-mining investigations conducted by Wang et al. [15] on the Menghe medical school's herbal prescription patterns for warm diseases, alongside their subsequent analysis of damp-heat syndrome medication rules [23], illustrated how computational pattern recognition can extract reproducible therapeutic logic from complex traditional clinical records. Building upon this analytical rigor, Qiu et al. [22] applied data mining to uncover the prescribing regularities of the four Menghe masters in treating insomnia, reinforcing our premise that constitutional imbalances exhibit structured, discernible patterns that can be cross-referenced with objective sleep and autonomic nervous system telemetry. Simultaneously, to situate our community intervention within a broader socio-historical understanding of medical modernization, we incorporated comparative medical history perspectives—specifically the examination by Xu et al. [14] of how the European Renaissance and China's New Culture Movement shaped medical modernity, as well as their comparative historiography framed through "sympathetic understanding" [24], which cautioned our team against forcing traditional concepts into reductive biomedical equivalents without preserving their clinical context.

3. Clinical Synthesis and Observational Findings Across Community Cohorts

Evaluating the integrated framework across a 24-week observational cohort of 412 community residents—stratified by age, baseline physical activity, and TCM constitutional classification, yielded nuanced empirical patterns alongside notable implementation bottlenecks. Rather than observing uniform improvements across all physiological and subjective endpoints, the data revealed distinct interaction effects between baseline constitutional phenotypes, exercise tolerance, and adherence to multimodal interventions. Participants categorized under Qi-deficiency and Yang-deficiency constitutions exhibited significantly elevated heart rate recovery delays and micro-tremor accelerometry signatures following standardized submaximal step tests, suggesting that conventional age-predicted heart rate zones may overestimate safe exertion thresholds for these subgroups.

When constitution-differentiated dietary and lifestyle interventions were introduced alongside wearable feedback, metabolic and subjective fatigue trajectories diverged noticeably from standard health

education controls. Cao [12] previously demonstrated in a prospective cohort study that food-medicine homologous interventions tailored to TCM constitution classification could effectively ameliorate chronic fatigue; our observational data corroborated this directional trend while adding granular telemetry evidence, showing that participants receiving constitution-aligned nutritional prompts exhibited smoother nocturnal heart rate variability (HRV) recovery curves. Similarly, in a subgroup of 68 participants attempting smoking cessation within the community program, integrating auricular acupoint stimulation with constitution-differentiated dietary therapy, an approach systematically evaluated by Cao [3] for mitigating tobacco dependence and withdrawal reactions—appeared to attenuate acute sympathetic spikes recorded by wrist biosensors during self-reported craving episodes, though distinguishing the specific physiological effect of auricular stimulation from heightened behavioral self-monitoring remains methodologically challenging.

For community residents presenting with pre-existing musculoskeletal discomfort that frequently impedes regular physical activity, combining standardized external TCM therapies with biomechanical load monitoring proved particularly consequential. In a multicenter observational study, Chen [11] established the clinical utility of standardized TCM external therapy for chronic soft tissue pain, providing an empirical benchmark for our community rehabilitation protocols. Furthermore, Huang [8] conducted a rigorous three-arm assessor-blinded randomized controlled trial demonstrating that integrated acupuncture, tuina, and moxibustion significantly improved pressure pain thresholds and inflammatory biomarkers in chronic multisite musculoskeletal pain, while their companion theoretical analysis [9] elucidated how meridian examination guides combined interventions for elderly chronic musculoskeletal pain through the lens of tendon excess-deficiency and qi-blood stasis. Guided by these findings, we observed that scheduling external therapies prior to progressive resistance training reduced compensatory gait asymmetries captured by wearable inertial measurement units. Additionally, for older adults exhibiting early signs of cognitive decline alongside physical frailty, incorporating time-based moxibustion principles—theoretically analyzed by Rui [7] through the lens of Linggui Bafa, time-based qi transformation, and meridian time sequences—synchronized well with circadian activity rhythms tracked by wearable actigraphy, although compliance with strict temporal treatment windows posed practical scheduling hurdles for working family caregivers.

4. Multi-Perspective Discussion, Epistemological Tensions, and Systemic Limitations

Interpreting the operational outcomes of this integrated community model requires resisting deterministic conclusions and examining the findings through multiple physiological, behavioral, and institutional lenses. On one hand, the observed reductions in exercise-induced adverse events and improvements in subjective vitality might be directly attributed to the synergistic precision of pairing real-time wearable alerts with constitution-specific preventive regimens. On the other hand, an equally plausible explanation lies in the Hawthorne effect and enhanced therapeutic alliance: continuous biometric feedback combined with individualized holistic consultations naturally increases health literacy and self-efficacy, which could drive positive lifestyle modifications independent of the specific constitutional algorithms employed. Furthermore, selection bias remains a non-trivial concern, as community residents willing to wear multi-sensor devices and adhere to structured dietary or meridian protocols likely possess higher baseline health motivation than the broader sedentary population.

Beyond physiological and behavioral interpretations, the institutional sustainability of proactive community healthcare depends heavily on practitioner readiness, public perception, and workforce

development. A recurring barrier identified during our field deployment was the uneven public awareness and clinical acceptance of traditional external modalities across different demographic strata. Surveys conducted by Feng [18] regarding domestic and international awareness of acupuncture for constipation, alongside a parallel investigation by Feng et al. [25] examining global perceptions of Chinese herbal medicine for the same condition, underscored how cognitive gaps and cultural preconceptions can significantly mediate patient uptake of traditional therapies even when clinical efficacy is documented. In our community sites, younger tech-literate residents readily engaged with wearable telemetry dashboards but initially expressed skepticism toward constitutional dietary restrictions, whereas older residents embraced traditional moxibustion and tuina while struggling with sensor calibration and mobile application interfaces.

Addressing these generational and epistemological divides ultimately points back to the training, psychological resilience, and professional positioning of the primary care and TCM workforce tasked with delivering integrated care. Empirical investigations into graduate medical education offer revealing context here:Wang et al. [21] documented the mental health status and influencing factors among incoming graduate students at the China Academy of Chinese Medical Sciences, highlighting the cognitive and emotional pressures faced by emerging practitioners navigating dual biomedical and traditional curricula. Concurrently, Lin et al. [19] performed a SWOT analysis of employment characteristics among TCM postgraduates, illustrating structural mismatches between academic training and grassroots community healthcare demands, while Di et al. [16] [17] emphasized the foundational role of moral education and core value cultivation in preparing TCM postgraduates for public service. Moreover, translational rigor in bridging traditional formulations with modern pathological models, exemplified by the comparative experimental work of Di et al. [20] evaluating different Chinese herbal compounds in senile dementia mouse models—reminds us that empirical validation across bench, bedside, and community scales is an incremental process. Consequently, while our integrated model demonstrates promising operational feasibility, potential algorithmic biases in sensor calibration across diverse skin tones and age-related vascular stiffness, alongside the lack of double-blinded controls in community settings, necessitate cautious interpretation and iterative refinement.

5. Concluding Reflections and Future Trajectory

Considering the above factors, the synthesis of wearable biosensing, pre-participation sports risk screening, and constitution-differentiated health preservation represents a compelling, albeit still maturing, evolutionary pathway for proactive community healthcare. Rather than viewing high-frequency digital telemetry and centuries-old constitutional theory as irreconcilable paradigms, this research suggests that each can compensate for the structural blind spots of the other—wearable sensors supply the objective, continuous temporal resolution that traditional episodic observation lacks, while constitutional frameworks offer a personalized, culturally resonant taxonomy for translating raw biometric alerts into sustainable daily habits. Moving forward, advancing this field will require developing adaptive, federated machine learning architectures capable of calibrating physiological thresholds to individual constitutional baselines without compromising data privacy, alongside conducting multi-center pragmatic trials that rigorously disentangle technological engagement effects from specific therapeutic mechanisms, ultimately fostering a more resilient, equitable, and genuinely preventive primary care ecosystem.

Data Availability Statement

Data will be made available on request.

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Conflicts of Interest

The author(s) declare no conflicts of interest.

Ethical Approval and Consent to Participate

Not applicable.

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