

## Clinical Communications: Adults



### “PERSISTENT JUVENILE” T-WAVE PATTERN MAY NOT BE PERSISTENT: CASE SERIES AND LITERATURE REVIEW

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**Abstract—Background:** T-wave inversions (TWI) can signify serious pathology, but may also represent a benign variant. One such variant has been termed the “persistent juvenile” T-wave pattern (PJTWP). It is characterized by TWI in the right precordium, and has been understood to represent an arrested stage of the normal electrocardiographic evolution from childhood. **Case Report:** A series of four African-American (AA) women, ages 20 to 43 years, presented to the Emergency Department, and were found to have right precordial TWI that was absent on prior electrocardiograms. The diagnostic evaluation did not reveal acute cardiopulmonary causes for these new TWIs. **Why Should An Emergency Physician Be Aware of This?** The “persistent” juvenile pattern may not be actually persistent in the individual patient. In an appropriate patient, such as a young AA woman, where acute cardiopulmonary disease has been reasonably ruled out, the finding of new right precordial TWI should not preclude the diagnosis of PJTWP. © 2015 Elsevier Inc.

**Keywords—**electrocardiography; T-wave inversion; persistent juvenile pattern

#### INTRODUCTION

Emergency physicians often have to interpret the significance of T-wave inversions (TWI) found in the electrocardiogram (ECG) (1). Such inversions may present a difficult diagnostic problem, as TWI can signify serious pathology, but may also represent a benign variant.

One such benign variant has been termed the “persistent juvenile” T-wave pattern (PJTWP). It is characterized by

TWI in the right precordium, and has long been assumed (as the name suggests) to represent an arrested stage of the normal electrocardiographic evolution from childhood.

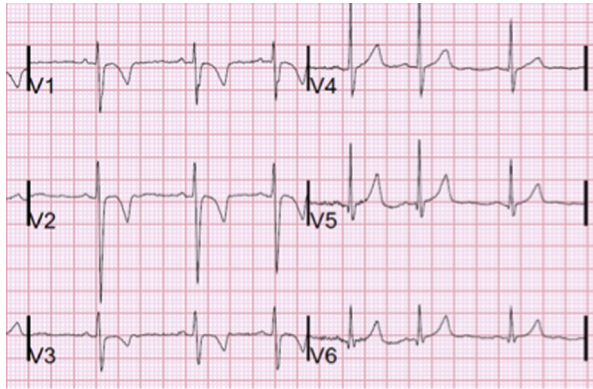
Young children are often found to have shallow T-wave inversions in the precordium, limited to V1–V3 (2). These inverted Twaves typically have an asymmetric morphology, with an initial slow descent to the nadir, followed by a briefer upstroke (3). Such TWI is limited to the right precordial leads during infancy. The T-waves then “flip” upwards in a progressive fashion, from left to right, during childhood. Figure 1 shows an example from a healthy 5-year-old child. This pattern, when found in adults, has been described as a “persistent juvenile” pattern, where the juvenile pattern has “persisted” since childhood (4). However, the literature does not support the assumption that such TWI is static, and some evidence suggests that TWI in PJTWP is more dynamic than usually appreciated.

We present 4 adult patients who presented with apparent PJTWP, but who had demonstrated a typical adult T-wave pattern on prior ECGs. We also review the early literature that first described PJTWP, focusing on how this pattern came to be described as “persistent.”

#### CASE REPORTS

##### Case 1

A 32-year-old African-American (AA) woman came to the Emergency Department (ED) complaining of



**Figure 1.** Precordial leads from the electrocardiogram of a healthy 5-year-old girl.

episodes of palpitations and a “racing” heart, but denied syncope. Her history was significant for type 2 diabetes mellitus, obesity, and hypertension. Vital signs and the physical examination were unremarkable.

An ECG (Figure 2) was obtained, and showed T-wave inversions > 1 mm in V2, and > 2 mm in V3. An ECG obtained 2 months after presentation showed a similar pattern (Supplementary Figure 1, Online Appendix). An ECG from 7 years prior demonstrated only minor TWI in V2 and a flat T in V3 (Figure 3). Another ECG from that year showed a flat T in V2, and trivial TWI in V3 (Supplementary Figure 2, Online Appendix).

An echocardiogram from 4 years prior was unremarkable. Cardiology consultation was obtained, serial troponins were negative, and outpatient re-evaluation was arranged.

#### Case 2

A 41-year-old AA woman presented with epigastric pain and nausea for the past day. Her history was significant

only for obesity and hypertension. Her epigastrium was tender to palpation, which reproduced the symptoms.

An ECG was obtained (Supplementary Figure 3, Online Appendix), which showed minor TWI in V1, V3, and V4. Marked TWI was seen in V1–V4 in her ECG from 2 years prior, however (Figure 4). An ECG from 13 years prior, at age 28 (Figure 5) demonstrated TWI only in V1. Interestingly, the earliest ECG in the database, obtained at 17 years of age, showed notable TWI in V1 and V2, and a bifid T-wave in V3 (Supplementary Figure 4, Online Appendix).

The patient's symptoms resolved with antiemetics, intravenous fluids, and antacids, and no further cardiac testing was pursued.

#### Case 3

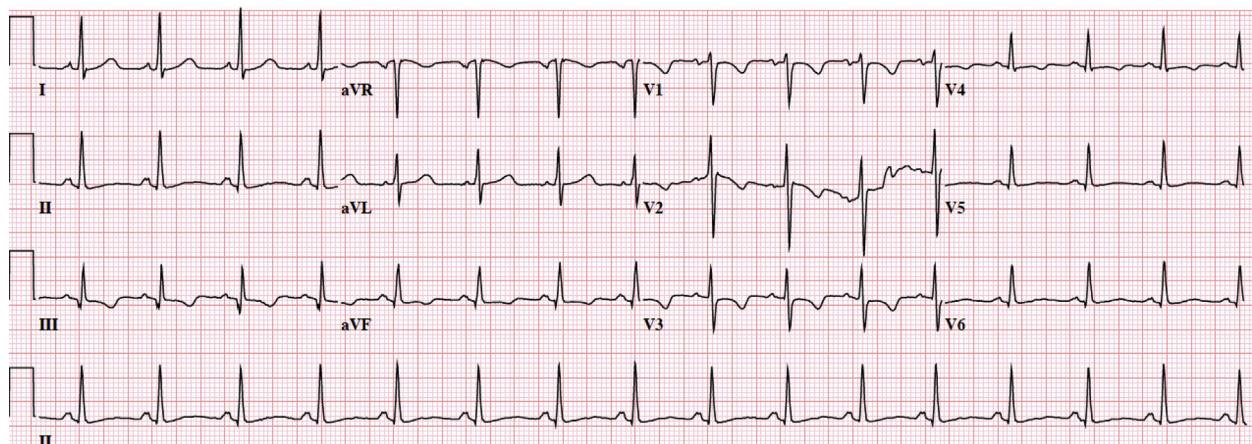
A 20-year-old AA woman presented with a pleuritic chest pain that had started some months prior. Her medical history was significant for morbid obesity, traumatic brain injury, and poorly controlled type 2 diabetes mellitus. The chest pain was reproducible with palpation.

An ECG demonstrated TWI in leads V1–V3 (Figure 6). A similar ECG from 1 month prior showed TWI in V1 and V2 (Supplementary Figure 5, Online Appendix). An ECG obtained 5 years prior (Figure 7), however, showed inversion limited to V1, a normal finding.

Both a D-dimer and a single troponin were negative, and she was discharged from the ED.

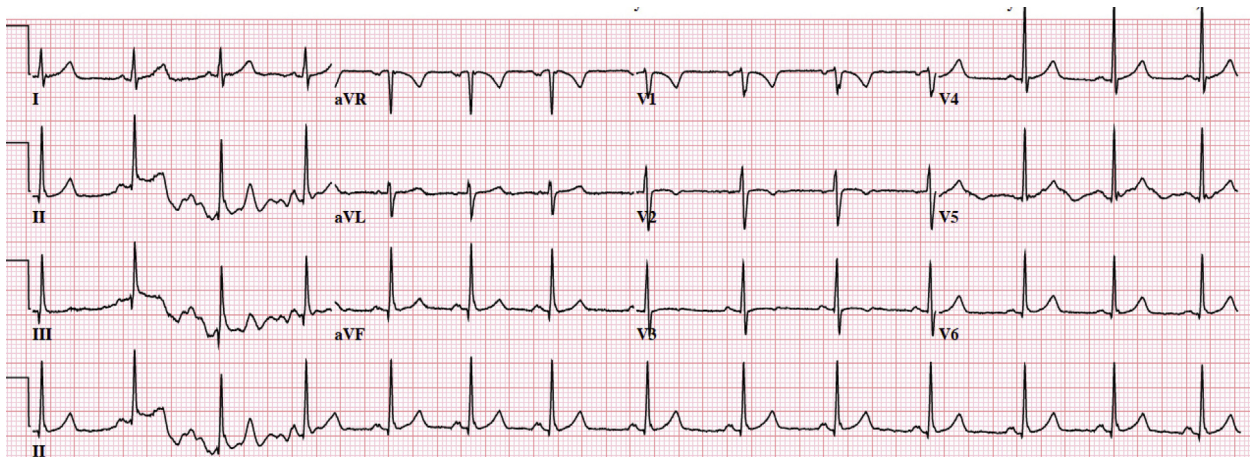
#### Case 4

A 43-year-old AA woman presented with 1 day of left flank and left lower quadrant pain. The examination was unrevealing, and basic laboratory studies were negative, as was a computed tomography scan of the abdomen and



**Figure 2.** Case 1, presenting electrocardiogram. There is T-wave inversion in V1–V3.





**Figure 3.** Case 1, electrocardiogram from 7 years ago. Shows only minor T-wave inversion in V2.

pelvis. The troponin level was detectable on serial testing, but was “negative” per the institutional threshold at the time.

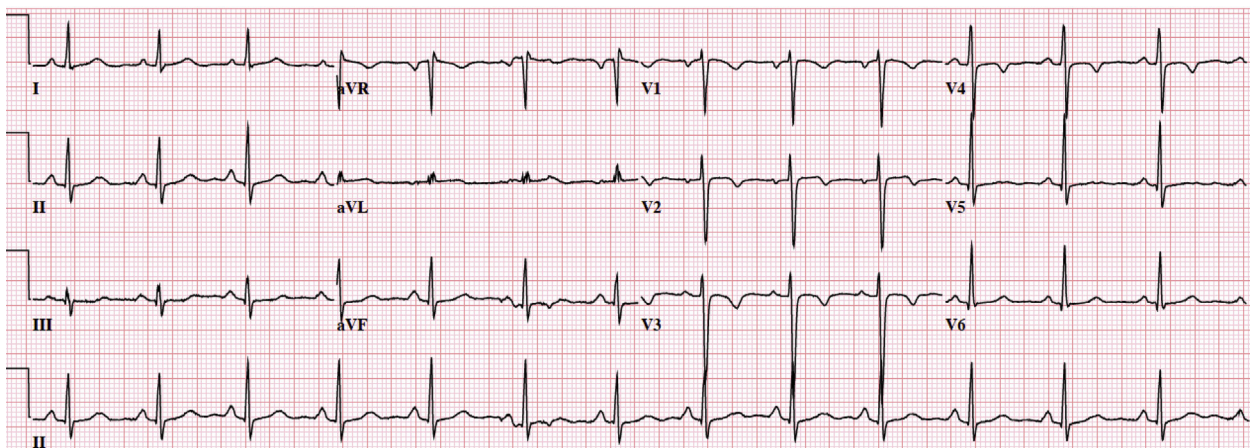
An ECG (Figure 8) showed TWI in V1–V3. An ECG from only 6 months prior (Figure 9), however, showed only trivial TWI in V1. Likewise, an ECG from 5 years prior also demonstrated only minor, nonspecific ST-T abnormalities in the precordial leads (Supplementary Figure 6, Online Appendix), whereas an ECG from 15 years prior showed fully upright T-waves in V2 and V3 (Supplementary Figure 7, Online Appendix).

The patient was admitted 2 months later for chest pain atypical for acute coronary syndrome (ACS). Serial troponins were indeterminate, but an echocardiogram found normal systolic and diastolic function, and did not reveal hypertrophy or regional wall motion abnormalities. An exercise ECG stress test did not provoke ischemic symptoms or ECG changes.

## DISCUSSION

These 4 patients all showed anterior TWI consistent with PJTWP. Prior ECGs, however, demonstrated that in each patient an “adult” pattern of T-wave orientation had already developed post adolescence.

There is considerable variation in what has been termed a “juvenile pattern” in the literature. Some studies in adults have used narrow criteria to define PJTWP (shallow, asymmetric TWI limited to V1–V3), while others offer examples of PJTWP that do not resemble the most common form of juvenile ST/T wave morphology (4). For example, at least three recent articles provide examples of right precordial TWI that the authors label as PJTWP, despite significant ST-segment elevation (STE) in those leads (5–7). This pattern of “domed” STE in the right precordial leads may be seen in adolescent and young adult males of Afro-Caribbean heritage, but is not common otherwise (8).



**Figure 4.** Case 2, electrocardiogram from 2 years ago. There is notable T-wave inversion in V1–V4.



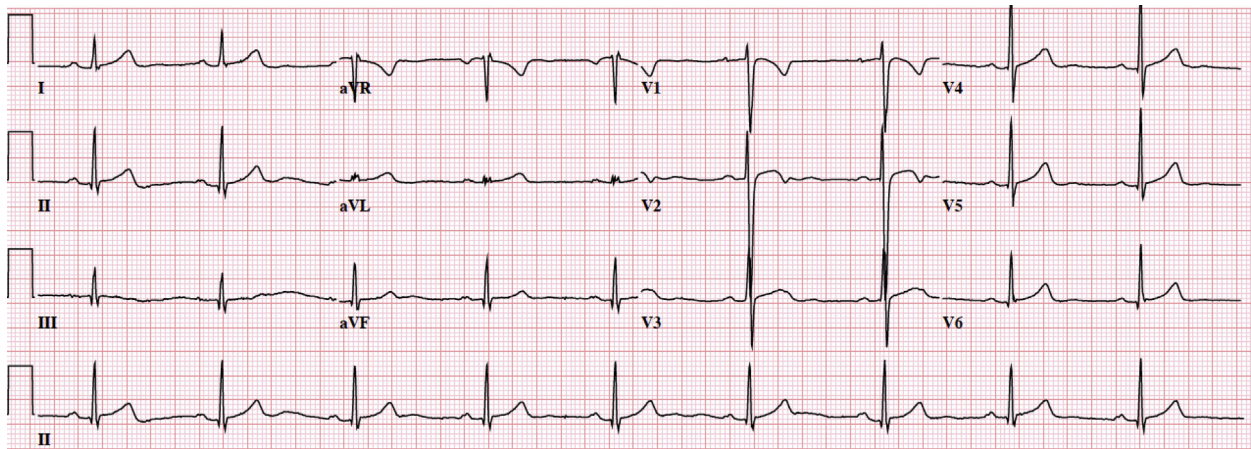


Figure 5. Case 2, electrocardiogram from 13 years ago. T-wave inversion is limited to V1.

PJTWP is more often found in women (4,9,10). Similar to other repolarization abnormalities, PJTWP is seen more often in patients of Afro-Caribbean heritage (6,10–12). A number of ECG variants have been described in highly trained athletes, and although some research suggests that anterior T-wave inversions are likely training related, other studies have not confirmed this (13–16). Authorities recommend further evaluation of adult athletes, particularly males, who are found to have significant anterior TWI (5,17–20).

A diagnosis of PJTWP should be made only after consideration of more dangerous causes of anterior TWI, because such changes could reflect severe chronic obstructive pulmonary disease, pulmonary embolism (PE), acute myocardial infarction, or pulmonary hypertension. In particular, especially in the context of syncope, the clinician should consider the possibility of dysrhythmogenic right ventricular cardiomyopathy, as it may often present with TWI in V1–V3 in patients > 14 years old (21). Although it is a well-established cause

of sudden cardiac death in Italian athletes, the prevalence in the United States is unclear (22,23).

#### *Four Explanations for the New TWI in Our Patients*

Our case series shows the ECGs of 4 AA women who developed PJTWP post adolescence, after the expected adult anterior T-wave pattern had already been observed in earlier ECGs. This “non-persistent” or “non-juvenile” TWI might be produced by at least four phenomena.

*A more serious diagnosis was missed.* The first and most concerning possibility would be that these patients do not have PJTWP, and were instead developing TWI secondary to another conditions. Definitive diagnosis with echocardiography or cardiac magnetic resonance imaging was not pursued in every case, and so it could be argued that early or subtle cardiopulmonary disorders could have been missed. However, two of the patients (#1 and #4) had negative serial troponin testing, as well as current

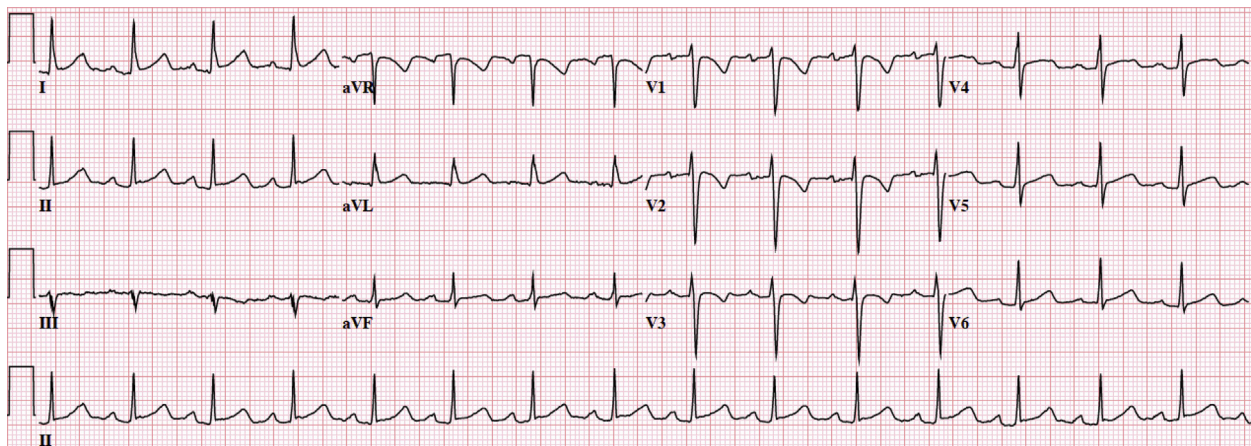


Figure 6. Case 3, presenting electrocardiogram. There is T-wave inversion in V1–V3.



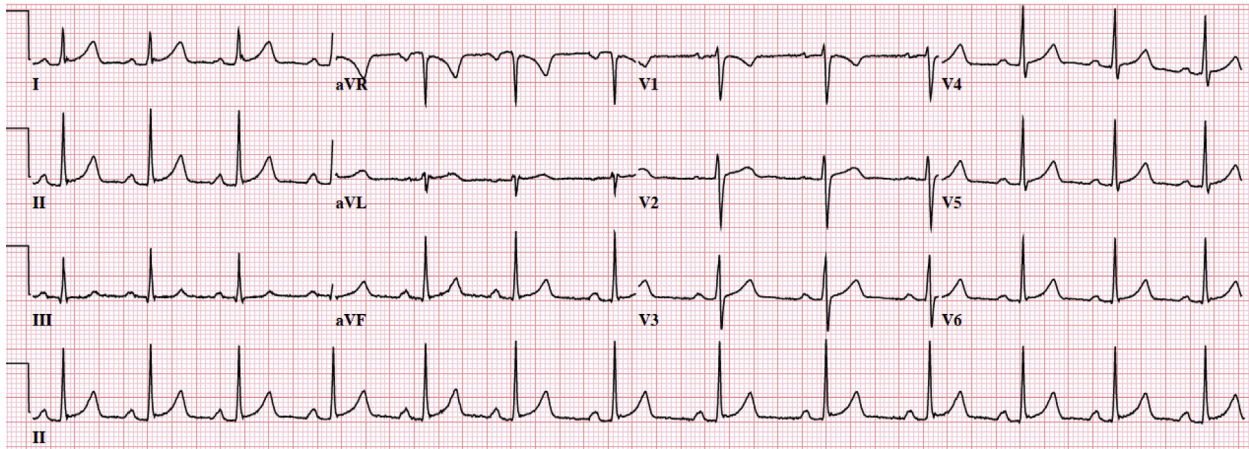


Figure 7. Case 3, electrocardiogram from 5 years ago. T-wave inversion is limited to V1.

or previous echocardiograms that did not reveal structural disease. Patient #4 had a negative exercise stress test, weighing against ACS. Although patient #2 did not receive echocardiography, her history and physical examination strongly weighed against a cardiopulmonary etiology. Patient #3 also had symptoms that were unlikely to reflect ACS or PE as a cause of the TWI, but nonetheless, a troponin and D-dimer were obtained, and were negative. Finally, although none had “persistent” juvenile T-waves, all had the typical morphology of juvenile T-waves, which is widely considered benign.

*The TWI was generated by poor lead placement.* Another possibility is that the ECG patterns are generated by erroneous precordial lead placement. Misplacement of V1 and V2 upwards on the chest is common, and is known to produce ST and T-wave changes (24). In particular, placement of V1 and V2 in the second or third intercostal spaces has been shown to produce TWI in V1 and

V2 (25–27). However, misplacement of V3 has not been known to generate TWI. In addition, multiple ECGs on various dates were obtained in each patient, so that the chance of a technical error causing this pattern seems unlikely.

*PJTWP is a dynamic phenomenon.* The last possibility is that the PJTWP may simply represent one of a wide range of repolarization variants. Certain of these variants, such as early repolarization or the “ST-T wave-normal variant” (STTNV) are seen more often in people of African heritage (8,28). Much like early repolarization or STTNV, these ST and T wave variants may be dynamic over a patient’s life (8,28,29).

#### *Focused Review of Literature on PJTWP*

There is little evidence that the so-called “persistent” juvenile pattern is, in fact, persistent and invariant from

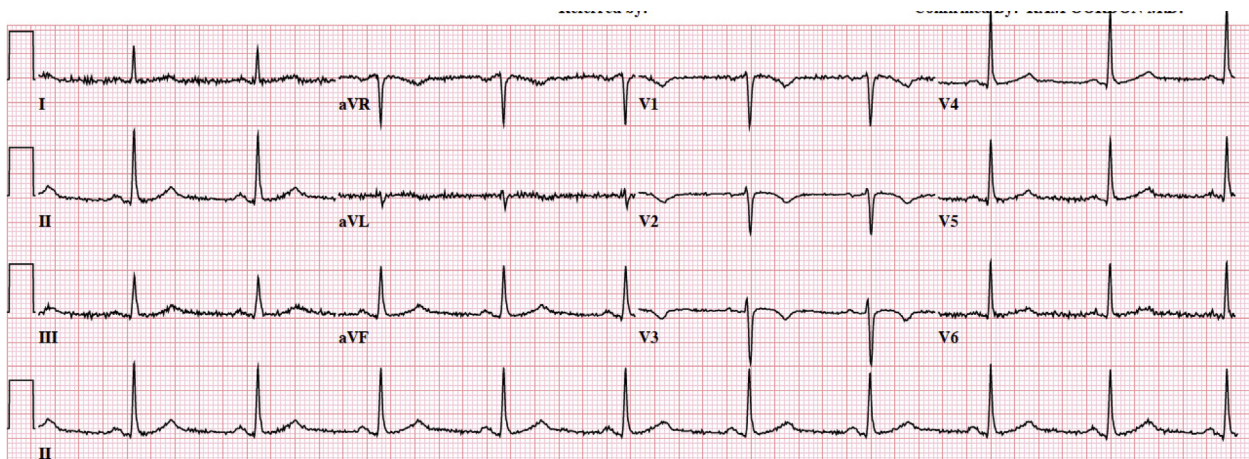
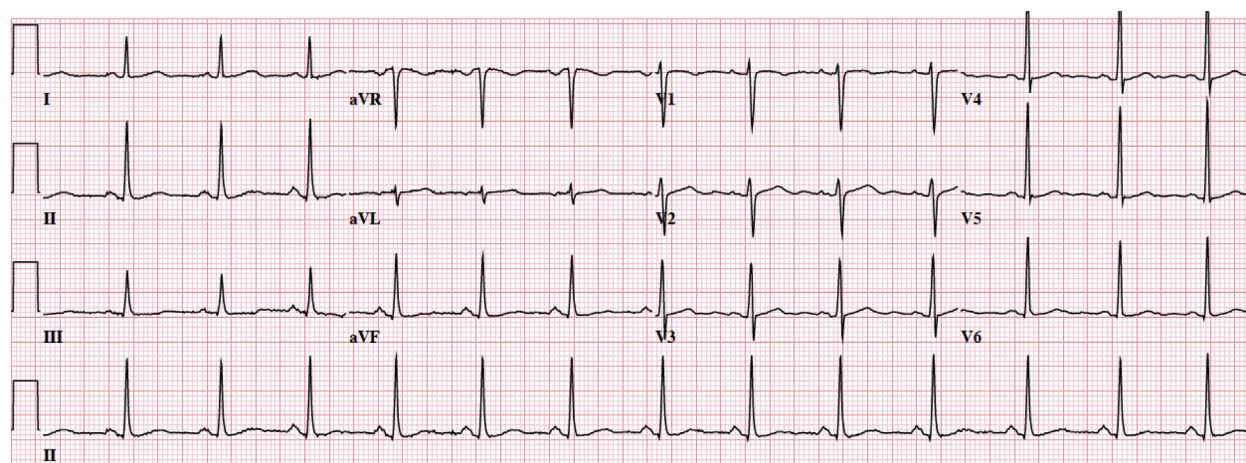


Figure 8. Case 4, presenting electrocardiogram. There is T-wave inversion in V1–V3.



**Figure 9.** Case 4, electrocardiogram from 6 months ago. T-wave inversion is limited to V1.

childhood. The term “persistent juvenile pattern” was first used by Littman in 1946 (30). He used it as shorthand, describing “juvenile” vs. “adult” patterns, because he saw that the T waves were generally oppositely directed (between adults and children) in the precordium. Although he described the juvenile pattern as “persistent,” he did not suggest that such a pattern had been invariant since childhood. Indeed, he noted, “It is uncertain that the erection of a juvenile T wave is a continuous progression and not an unsteady equilibrium, [which could be] possibly transient or shifting in character.” He cited earlier articles that showed the orientation of precordial T-waves could vary over the course of months in children, and did not show a clear pattern of evolution (31).

Subsequent studies affirmed that the T waves in the right precordial leads were often inverted in children. A 1946 study of healthy Puerto Rican children and adults found this pattern more often in females than males, and more commonly in children than adults (3). They suggested that right precordial TWI in V1 in adult males, or V1–V3 in an adult female, could be considered a benign variant. Another study found that almost 20% of children < 11 years of age showed TWI up to V4 (32). Similarly, a 1949 study of healthy children and adults found that TWI in V3 was “rare except in children” (33).

Literature in the 1950s and afterward started to employ the term “juvenile pattern” more frequently. Keller and Johnson described a “persistence of a juvenile ECG pattern” in only 1 out of 85 healthy young adult AA patients (34). Grusin noted a pattern of precordial TWI with associated “evolving” ST-segment deviations, and stated that it would be “tempting to speculate that the electrocardiogram of the African may be of a juvenile type in the developmental sense” (35). Wasserburger found that 11% of healthy adult AA males manifested what he described as a “juvenile pattern,” defined as “frank inversion of the T waves in the right and mid-precordial leads”

(36). Gottschalk and Craig also found that a “persistence of the juvenile T-wave pattern” was more common in AA subjects than in white subjects (37). Specifically, only AA females showed TWI in V2 or V3.

Thomas et al. used the term “juvenile pattern” to describe the TWI seen “as far as lead V3,” with no role of ST-segment deviation, in up to 5% of young AA adult women (38). Blackman and Kuskin noted a “juvenile pattern” of right precordial TWI in 5 adolescents (39).

Many of these studies that characterized a “juvenile” pattern have described features that would be abnormal in a juvenile ECG. Rafailzadeh et al. made reference to a “juvenile T wave pattern” consisting of “striking T wave inversions,” but in the context of a young AA male who also had notable anterior ST-segment elevation (40). The unwary reader would conclude that they considered this pattern to be a typical juvenile pattern. Reiley et al. used the term “juvenile pattern” in the context of actual juveniles, but expanded the definition to comprise not only right precordial TWI, but also precordial ST-segment elevation, as well as increased precordial QRS voltage (41). By contrast, a study in an Indian population defined the “juvenile T-wave” as an “inverted T wave descending slowly and rising abruptly to the baseline ... producing an asymmetrical T wave” (no role of ST-segment deviation was detailed) (42). They found such a pattern exclusively in patients < 21 years of age.

None of the literature suggests that the “juvenile” pattern of TWI is stable. As noted above, the person who first coined the term did not believe that such a pattern was necessarily “persistent” in the individual patient, whereas Grusin noted that the T-wave orientation could be dynamic in young individuals over time (30,35). Furthermore, the term “juvenile pattern” has often been used to describe an ECG pattern that should be considered abnormal in the general pediatric population (i.e., precordial ST segment elevation).



## WHY SHOULD AN EMERGENCY PHYSICIAN BE AWARE OF THIS?

Our case series suggests that a so-called "persistent juvenile" T-wave pattern may not represent a truly arrested form of the juvenile's ECG. Our literature review reveals that the term was likely a misnomer from the very beginning. Right precordial T-wave inversions in a young adult, especially a female of Afro-Caribbean heritage, may be a benign variant even if they are new or "non-persistent."

## SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at <http://dx.doi.org/10.1016/j.jemermed.2015.06.064>.

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